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PROCEEDINGS

ABSTRACTS OF PAPERS, 84th Annual Meeting of the Virginia Academy of Science, May 25-26, 2006, Virginia Polytechnic Institute and State University, Blacksburg, VA

Aeronautical and Aerospace Sciences

A LOGISTIC AIRCRAFT CONCEPT. M. Leroy Spearman, NASA-Langley Research Center, Hampton, VA 23681 & Katie Klein, MITRE Corp., McLean, VA 22102. Airlift and sealift capability could be useful as a means of providing the logistic support of manpower, supplies and equipment in the event of natural disasters or in the event of warfare. Such events could be within the homeland area or could be at distant locations. Such support may be required rapidly and to locations inaccessible by normal means of transportation. Conventional aircraft can provide the need for speed but the load capacity may be limited. The use of aircraft is also dependent on the basing for take-off and landing. Water-based vessels can provide large load-carrying capability but the speed is limited and water ports must be available. An effort to combine the requirements for capacity, speed and basing, has lead to some research relative to unconventional designs. The concept considered has a large rectangular wing surface mounted inboard of large bodies that are attached to each wing tip. The use of two bodies of a conventional aircraft design results in doubling the capacity of the conventional aircraft. The large area of the rectangular wing provides adequate lift to sustain flight. In addition, if the wing was positioned near the surface, a cushion of air would be provided that would permit operation as a wing-in-ground (WIG) effect vehicle. Another possibility considered was the use of a portion of the bodies as containers for helium gas that would permit operation as a hybrid airship with vertical take-off and landing (VTOL) capability. Thus, the inboard wing arrangement potentially provides for large load carrying capability with a vehicle that could operate in free-air as an airplane, or near the surface in a WIG mode, or have greater basing freedom in a VTOL mode.

A CONCEPT FOR A LARGE TRANSPORT AIRCRAFT. M. Leroy Spearman, NASA-Langley Research Center, Hampton, VA 23681 & Karen Feigh, GA Inst. of Technology, Atlanta, GA 30332. The basic wing-body-tail arrangement of conventional transport aircraft has remained essentially unchanged over the years. Increased capacity has been achieved simply by increasing the overall size of the aircraft. However such an approach may be limited for aircraft beyond the size of the current jumbo jets such as the Boeing 747. Limitations may occur in the manufacturing process. There may be limitations in ground handling and in access to the boarding gate. A serious problem may occur from the trailing tip

vortex, which would be much stronger than that for current transports because of the increased lift required for the larger aircraft. In an effort to alleviate such problems some research has been done with an unconventional design for a large aircraft. The design has a large rectangular wing surface mounted inboard of large bodies attached to each wing tip. There are no outboard, cantilevered wing panels such as those that are found on conventional aircraft designs. The use of two bodies of a conventional aircraft design results in doubling the capacity of the conventional aircraft. The large area of the rectangular wing provides adequate lift to sustain flight. The tip-mounted bodies act as end plates for the wing and the formation of a trailing vortex is precluded. Wind tunnel tests have been made of such a concept using two B-747 fuselages. The resulting concept provides a payload capacity twice that of a B-747 with no increase in length, less span, and no tip vortex.

SOME CONCEPTS IN THE HISTORY OF FLIGHT VEHICLE DESIGN – PAST, PRESENT, FUTURE. M. Leroy Spearman, NASA-Langley Research Center, Hampton, VA 23681 & Jill Harper, GWU, King George, VA 22485. Since the mind of man first considered the prospect of flight, there has been remarkable growth in the field of aviation. Leonardo Da Vinci, the Italian artist and inventor, designed what appeared to be a practical airplane in 1490. Da Vinci also observed that birds had a wing surface that had a greater curvature on the upper surface than on the lower surface. He deduced that forward motion was necessary to produce airflow over the wing and that the difference in local velocity over the curved wing would create a pressure difference that had an upward force. The airflow over the wings could be achieved by gliding flight down a slope or flight into the wind. Thus a number of glider designs began to appear that included those by Lilienthal, Langley and the Wright brothers. Rotating the wings like a fan could also induce the airflow over the wings. Thus some rotary-wing designs similar to today's helicopter also appeared. It was about 400 years after Da Vinci that Langley's "Aerodrome" model flew in the United States in 1896. Then, in December 1903, the Wright Brother's in the U.S were credited with the first flight of a manned, powered aircraft. Over the years there have been numerous aircraft designs that have included variations in wing shape and location, tail shape and location, body shape and location, propulsion system arrangement and so on. However, the specific shape is relatively unimportant provided that the lifting surface area and the propulsive airflow system is able to produce enough lift to overcome the weight of the vehicle.

Agriculture, Forestry and Aquaculture Science

CENTRAL ADMINISTRATION OF NEUROTENSIN DECREASES FEED INTAKE IN GOLDFISH. Marissa L. Smith and Mark A. Cline, Department of Biology, Radford University, Radford Virginia, 24142. Neurotensin (NT) is an anorexigenic tridecapeptide found in the hypothalamus and intestinal tracts of mammals and birds. The effects of NT in fish are unreported. Thus we conducted an experiment to determine the effects of NT on feed intake in goldfish. Goldfish (n=39) were centrally injected with 0, 0.25, 2.5, 25 µg NT dissolved in teleost saline

as vehicle. Following injection, fish were fed a 4% body weight ration of fish feed pellets and digital overhead photographs were taken every 10 min for 90 min and cumulative feed intake was later quantified from the photographs. The treatment effect began at 40 min post feeding and lasted through the end of the observation period at 90 min. NT linearly decreased feed intake from 50-90 min post feeding. These results indicate similarities in the neurotensin-regulating feeding system between mammals and fish.

EFFECTS OF CENTRAL AND PERIPHERAL XENIN ADMINSTRATION ON APPETITE, FEED PASSAGE TIME , AND BRAIN CHEMISTRY IN 4-DAY POST HATCH CHICKS. <u>Wint Nandar</u>, J. Orion Rogers and Mark Cline, Neurophysiology & Behavior Lab, Dept. of Biol., Radford Univ., Radford, VA 24142. The 25 amino acid peptide xenin is found in the gastric mucosa and central nervous system of mammals. In mammals, xenin plasma concentration increases after a meal, reduces feed and water intake and causes altered intestinal contractility. The biological role of xenin in avian is unknown. We conducted a study to determine the effects of xenin on appetite and food transit time in 4-day post hatch chicks. Intraperitoneal injection of either 0.2, 2.0 or 20 μg of xenin caused a quadratic reduction in feed intake after 150 min post injection with no effect on water intake in chicks. Intracerebroventicular (ICV) injection of 0.75, 1.5 or 3.0 μg of xenin caused a linear dose dependent decrease in feed intake after 30 min post injection with no effect on water intake and food transit time through the total alimentary cannal. ICV injection of 3.0 μg of xenin and c Fos cells expression in chicks hypothalamus was detected immunocytochemically. Xenin activates ventromedial hypothalamus but not lateral hypothalamus. This study was supported by Virginia Academy of Science Undergraduate Research Grant.

WHITE LUPIN: A NEW ALTERNATIVE WINTER LEGUME CROP FOR VIRGINIA. Harbans Bhardwaj, Virginia State Univ., Petersburg, VA 23806. White lupin (*Lupinus albus* L.) has the potential to meet N needs of succeeding crops and to provide high protein grains to meet the food needs of increasing world population. However, detailed information about N_2 fixation (BNF), and forage and grain crop performance of lupin, in the mid-Atlantic region, is not available. We studied BNF as related to lupin seed composition and conducted field experiments at three locations (Orange, Petersburg, and Suffolk) with 20 lupin lines in Virginia during 2003-04 season. Evaluation of 126 accessions indicated that alkaloid content affected root nodulation score. In general, bitter-seeded lines had higher nodulation score as compared to sweet-seeded lines. The fresh forage yields (kg/ha), averaged over 20 lines, varied from 12624 (Petersburg) to 5352 (Orange). The fresh yields averaged over three locations, among 20 lupin lines, varied from 1276 to 10714. The seed yield varied from 127 to 3008 kg/ha, harvest index varied from 9 to 49 percent, seeds per pod varied from 2.6 to 4.4, 100-seed weight varied from 18.7 to 21.6 g, and plant height varied from 58.9 to 71.7 cm. The mean seed yields at Orange, Petersburg, and Suffolk locations were 2488, 1975, and 1928 kg/ha, respectively. Seed yield exhibited a significant positive correlation with plant height, pods/seed, and harvest index. The results indicated that lupin can be potential alternative grain crop in Virginia and the mid-Atlantic region.

GROWTH COMPARISON OF CAGE-REARED RAINBOW TROUT FED SALMON VERSUS CATFISH DIET. B. Nerrie, C. Jones, T. Boyd, and R. Booker. School of Agriculture, Virginia State University, Petersburg VA 23806. Winter cage culture of rainbow trout (*Onchorhynchus mykiss*) is an important component of agriculture diversification in Virginia. This study coincides with the academic year and provides an opportunity for undergraduate aquatic science students to benefit from practical knowledge of daily aquaculture production management in addition to research methodology. Trout (58 g) were stocked at 50 fish per cage in four cages on December 2, 2005 and raised for 139 days. Trout were fed daily at a rate of 225 g of feed per cage. Fish in two cages were provided a catfish fingerling floating feed pellet (36% protein). Fish in the other two cages were provided a floating salmon fingerling feed pellet (42% protein). Fish were harvested on April 25, 2006. Water temperature and dissolved oxygen concentration were measured daily. Temperature ranged from 5.8-22.3 °C. Supplemental aeration maintained the dissolved oxygen concentration at >90% saturation over the entire production period. Mean harvest size for individual fish and feed conversion for the catfish feed was 236 g and 1.55. Mean harvest size for individual fish and feed conversion for the salmon feed was 257 g and 1.4. Based on feed cost alone, use of lower cost feed would provide higher returns. However, the slower growth rate would require purchase of extra trout adding to costs.

THE BIOLOGICAL SIGNIFICANCE OF BIOACTIVE PEPTIDES. Ali I. Mohamed, Jennifer Hill, & Hee-Jeong Bahng, Department of Biology, Virginia State University, Petersburg, VA 23806. Soy proteins have many bioactive components including protein subunits, and bioactive peptides (BPs). Interests in BPs grown since potential anti-carcinogens and other therapeutic agents have been identified. Using soy protein hydrolysis by several processing methods, numerous BPs with various specific biological activities have been found. These include BPs with the following properties: antihypertensive, hypocholesterolemic, antiobesity, opioid agonistic and antagonistic, antioxidant, anticancer, immunomodulatory and antimicrobial. Recent report showed that peptides containing 5-20 amino acids are the most potent hypocholesterolemic components of soy protein in animals and humans. BPs showed antimicrobial activity. These new antimicrobial peptides are of great practical importance given the rapid evolution of bacteria that are resistant to multiple antibiotics overuse by humans and livestock. Plants produce cysteinerich antimicrobial peptides such as thionins, and purothionins, defensins and and lipid transfer proteins either a priori or in response to microbial invasion. Their activity is based on the inherent amino acid composition and sequence. Peptides classified as prebiotics generally exhibit 1. limited hydrolysis and absorption in the upper gastrointestinal tract; 2. selective growth stimulation of beneficial bacteria in the colon; and 3. potential to repress pathogens and limit virulence through stimulation of a beneficial flora. Therefore such nondigestible peptides can beneficially affect the host animal by selectively stimulating the growth and/or activity of beneficial bacteria in the colon.

THE STATUS AND CONDITION OF VIRGINIA'S FORESTS, 2001. Anita K. Rose, USDA Forest Service, Southern Research Station, Forest Inventory and Analysis, Knoxville, TN 37919. Between 1997 and 2002, the USDA Forest Service's Forest Inventory and Analysis (FIA) program conducted the 7th inventory of the forests of Virginia (n_{plots}=4404). Approximately 15,844,000 acres, or 62%, of Virginia was forested. The majority (12,102,000 acres) of Virginia's forestland was in nonindustrial private forest ownership. Public ownership and forest industry ranked 2nd and 3rd, with 2,718,000 and 1,024,000 acres, respectively. Red maple *(Acer rubrum* L.) dominated the number of live stems ($\geq$ 1.0 inch dbh) with 1.5 billion stems (13 % of total). Loblolly pine *(Pinus taeda* L.) was 2nd, with 959 million live stems, of which, 72% were in stands classified as planted. Yellow-poplar *(Liriodendron tulipifera* L.), sweetgum *(Liquidambar styraciflua* L.), and blackgum *(Nyssa sylvatica* L.) ranked 3rd, 4th, and 5th by number of stems. Yellow-poplar dominated the total live-tree volume with 5.5 billion cubic feet (13% of total). Loblolly pine was the 2nd most dominant species, with 4.7 billion cubic feet (11% of total). Chestnut oak (*Quercus prinus* L.), white oak *(Q. alba* L.), and red maple ranked next in total live-tree volume. Across Virginia, 95% of forest health plots (n_{plots}=110) had an average crown dieback $\leq$ 7.5%. Scarlet oak *(Q. coccinea* Muenchh.) and sourwood *(Oxydendrum arboreum* (L.) DC.) had the highest percentage of trees with $\geq$7.5% dieback. On sites with soils samples (n_{plots}=74), most had a pH < 5.0.

USING VOLATILES FROM THE LEAVES OF *VERNONIA GALAMENSIS* TO CONTROL INSECT PESTS. F. Favi & M. Kraemer. Agricultural Research Station, P.O. Box 9061, Virginia State University, Petersburg VA 23806. Insecticidal properties of plants belonging to the *Vernonia* genus has been well documented, including centuries of use by African tribes. We tested volatiles from the leaves of *Vernonia galamensis* (Cass.) Less as an alternative to methyl bromide, a fumigant rescheduled to phase out by 2010 due to its capability to deplete atmospheric ozone. Plant volatiles from leaf extract were released at room temperature and tested against adult whiteflies and confused flour beetles. One and two hundred microliters of our extract significantly killed adult whiteflies within an hour (F = 7.86, df = 7, p = 0.0022) and continued to be active for twenty hours (F = 10.60, df = 5, p = 0.0010). There was significant mortality of confused flour beetles fumigated with 3 mL of plant extract within twenty hours (F = infinity, df = 4, p = infinity) whether they were under one gram or ten grams of flour. However, no mortality was observed by the same quantity of plant extract when beetles were under 500 g of flour.

EFFECT OF LOW WINTER LIGHT INTENSITY ON GREENHOUSE TOMATO PRODUCTION, PLANTING SCHEDULES AND ENERGY COSTS. Mark Kraemer & Françoise Favi, Agricultural Research Station, Virginia State University, Petersburg, VA 23806. Winter greenhouse tomato production provides supplemental income to limited-resource producers during the late winter and spring. Seeds are planted as early as late October or as late as February. Early planting has become popular because it allows earlier harvest, but it also incurs additional heating costs and the potential for blossom drop and other problems

related to low light levels. Photosynthetically available radiaion (PAR) was monitored within two greenhouses, one in Virginia and the other in North Carolina. This data was used to calculate the maximum fruit load a tomato plant could support, and compared with actual fruit load. The greater the number of developing tomato "hands" (fruit clusters) per plant, the greater the amount of PAR light that is required to maintain this fruit production. We found that mid-winter light levels in our region were sufficient for good early development of tomato plants. However, light levels in late winter and early spring were sometimes not high enough to support plants with large fruit loads. Blossom drop and poor ripening was observed after periods of cloudy weather and this later resulted in poor harvests. We concluded that early planting of tomatoes was risky because it allowed plants to develop faster and produce more fruit than the available PAR light could support during periods of cloudy weather in late winter and early spring. Later planting could avoid this problem and reduce winter heating costs. New techniques of greenhouse temperature modification may allow earlier planting for more sophisticated greenhouse operations.

COMBINATION STOCKING OF TROUT SPECIES FOR CAGE CULTURE IN FARM PONDS. Scott H. Newton, Virginia State University, Petersburg, VA 23806. Since 1985, research has been conducted at Virginia State University on winter culture of trout in farm ponds in the Central Piedmont Region of the state. Studies have focused on use of floating plastic cages to rear fish in confinement similar to the practice of growing rabbits and chickens. Research experiments, along with industry results, have shown that winter cage culture of rainbow tout, golden trout, and brook trout is biologically feasible. A test demonstration, based upon documented research, was conducted to evaluate the combined aspects of a practical production and marketing scenario. Four different kinds of trout, totaling 500 fish, were stocked into one cage in the fall, 2005. In early spring, 2006, trout were randomly divided into two cages. Periodic harvests from the cages made beginning mid-March into early May. Production and sales data were summarized for farmer/producer information as it relates to small-scale agricultural diversification in existing farm ponds.

VIRGINIA FRESHWATER AQUACULTURE INDUSTRY: 1993 – 2003. Scott H. Newton, VSU, Petersburg, VA 23806. The first Virginia Aquaculture Survey was conducted for the production year 1993. Aquaculture survey forms and schedules were developed for producers along with the State Aquaculture Plan that was published in 1995. The 1993 survey established the status of both freshwater and marine commercial industries. The Virginia Agricultural Statistics Service (VASS) has published four survey reports for the years 1993, 1995, 1997, and 2003. These surveys have been conducted to track industry developments relevant to economic value of the Virginia industry. An analysis is provided on Virginia's freshwater aquaculture industry over a ten-year period along with recent comparisons with the North Carolina aquaculture industry.

WATER QUALITY FROM MULTI-BATCHING CATFISH PRODUCTON PONDS. David Crosby. Cooperative Extension VSU, PO Box 9081, Petersburg, VA 23806. Multi-batching catfish production project was initiated to simulate seine through water shed ponds in June of 2005. Five ¼ acre ponds were stocked with catfish weighting 55 lbs./1000 fish. Catfish were stocked at 5000 fish per acre. Fish were fed at 3% body weight daily with weekly feed adjustments. One of the objects of the project was to monitor and collect water quality data from June to September. Water samples were collected from each pond once a week in the afternoon before 3 pm. Water quality parameters that were tested included pH, TAN, and Nitrite. The pH ranged between 6.5 to 9 for all ponds. TAN were below 1 ppm for the entire study except for one pond spiking to 2.2 ppm briefly. Nitrites were consistently below 0.2 ppm for the summer. However, one pond did spike to nearly 1 ppm, but fell to 0.2 ppm level the following week. The overall water quality (TAN &Nitrite) for the first summer was considered very acceptable for this type of catfish production system.

Astronomy, Mathematics and Physics
&
Materials Science

COMPUTATION AND PHYSICS ASPECTS OF NON-EQUILIBRIUM MICROSYSTEM FLOWS. H. HU, Hampton University, Department of Mathematics, Hampton, Virginia 23668. In conventional fluid mechanics, the fluid behaves as a continuum and "sticks" to the surface of the boundary. The classical Navier-Stokes equations with no-slip boundary conditions for momentum and heat transfer in fluid flows work very well in modeling everyday flow situations where fluids maintain conditions of thermodynamic equilibrium. However in micrometer-length scale devices, flow behaves change and the continuum hypothesis may break down. Some unusual physics effects occur in microsystem flows. Microsystem flows are typically in the regimes of slip-flow and transition-flow. Fluid flows in transition-flow regime are too dense for molecular models, such as Molecular Dynamics Simulations or Direct Simulation of Monte-Carlo, and too rarefied for continuum models, such as Navier-Stokes models. The physics and computation aspects of flows in microsystems are examined. Extended hydrodynamics methods are discussed. Work-in-progress of developing numerical simulation schemes using extended hydrodynamics method of Burnett model for micrometer-scale flows is presented. The study focuses on some key issues of microsystem flows, such as the capability of the Burnett model and its numerical stability.

DEVELOPMENT OF A CONTROL SYSTEM FOR THE CLAS12 DETECTOR USING FPGA'S. Michael K. McGrath & Kevin L. Giovanetti, Dept. of Physics, Dept. of Physics and Astronomy, JMU. Control is an important element in large detection systems. These systems require complex control of detector voltages, readout and digitization, and calibration instrumentation. This ensures replication of the desired signals, proper mimicking of actual experiments, and proper timing and coordination. As experiments have become too complicated for manual

control, there is a need for electronic control over all aspects of the processes. Members of the James Madison University Physics Department have begun development of FPGA's for use in the 12 GeV upgraded CLAS detector at Jefferson Lab. The CLAS12 detector measures the momentum and velocity of various particles as they are emitted from electron-proton collisions. The goal of the CLAS12 detector is to study the structure of nucleons and nuclei. The FPGA will be used to control calibration systems for the experiment. It sends out various signals at specific time intervals and communicates and reacts with the detector. This allows for more elements of the calibration process to be automated, thus enabling more accurate detection due to the ability to mimic experiments. As a first step, an FPGA has been programmed to set the light output of an LED. Details of the program and associated electronics will be presented.

SOME INTERESTING SYMMETRIES OF THE GRAVITATIONAL STRESS ENERGY TENSOR. Joseph D. Rudmin, James Madison University. An isotropic metric for a black hole and a better vacuum condition ($\tilde{N}V_G^2 = 0$) are presented which yield distinct terms for the energy densities of ordinary matter and gravitational fields in the Einstein tensor ($G^{44}=-g^2(2\tilde{N}^2V_G+(\tilde{N}V_G)^2)$). This model resolves an inconsistency between electromagnetism and gravity in the calculation of field energy. Resolution of this inconsistency suggests a slight modification of the Einstein equation to $gG^{\mu\nu}=8\pi GT^{\mu\nu}$. Initial work on a general relativistic model for calculating electron mass will be briefly presented.

AXISYMMETRIC FIELD CALCULATIONS AND THE COMPLETE ELLIPTIC INTEGRAL OF THE FIRST KIND. Joseph W. Rudmin, Dept. of Physics and Astronomy, JMU. The Complete Elliptic Integral of the First Kind, designated K(m), frequently arises in the calculation of axisymmetric fields and potentials. One such example, which has widespread application, is the finding the magnetic field of a solenoid. It can be seen that this can be reduced to calculating the potential of a uniformly charged circular disk. Rapid precise calculation of this potential requires a computation of K(m), but in spite of its widespread use, it is still a poorly understood function. Current methods of computation (infinite series, the method of the arithmetic-geometric mean, and Hastings' Approximation) each have drawbacks. These will be discussed. A new infinite series for K will be presented, and certain beautiful symmetries, which have enabled some progress, will be shown.

THE DETERMINATION OF RELATIVE CONCENTRATIONS OF HYDROGEN ISOTOPES. Laurence A. Lewis & C. Steven Whisnant, Dept. of Physics, James Madison Univ., Harrisonburg VA. 22807. The JMU photonuclear group operates a hydrogen distillery to purify hydrogen deuteride to concentrations greater than 99.99% for use in producing polarized nucleon targets. Initially, the gas sample is approximately 98% HD with small admixtures of H_2 and D_2, undesirable contaminants in the target production process. Using low-temperature gas chromatography, samples of the distilled gas are analyzed to determine the relative concentrations of the isotopes H_2, HD, and D_2. The result is a chromatogram

containing two small peaks (the H_2 and D_2) not well resolved from much a larger peak (the HD). The gas chromatography software does not allow a detailed analysis of the curves in such a situation. Hence, a separate peak fitting procedure is being developed. One method being explored represents the peak shape using the HD line shape taken from a chromatogram of very pure HD. By shifting and scaling this empirical line shape, a general peak can be characterized with three parameters: the centroid, width, and normalization. This method provides an efficient model for fitting the chromatograms. Once a viable parameterization is established, a code will be developed to fit the model to the data and estimate the uncertainties of the free parameters by minimizing c^2. From the resultant peak areas, the relative concentrations are computed. These will be correlated with the polarization decay times of polarized targets produced from this gas at Brookhaven National Laboratory.

USING NEURAL NETWORKS TO MODEL ELECTRON-NUCLEON CROSS-SECTION. John A. Tellfeyan, Gabriel Nicolescu, Ioana Nicolescu, Dep. of Physics and Astronomy, JMU. Jefferson Lab Is currently producing data on the nucleon cross section. The cross section affects how their electron beam scatters off of nucleons. It is convenient to use artificial neural networks, also known as multi-layer perceptrons, to analyze this data. Neural networks simulate the activity of a few neurons in the brain. With a set of test data, a user can train them to find a pattern or polynomial equation that represents the data. This talk will outline the theory behind neural networks and how they apply to the problem of the neutron's cross section.

Biology

EFFECT OF EXOGENOUS CORTICOSTERONE ON RESPIRATION IN A REPTILE. S.E. DuRant[1], W.A. Hopkins[1], L.G. Talent[2], & L.M. Romero[3] [1]Virginia Polytechnic Institute and State University, Department of Fisheries and Wildlife Sciences; [2]Oklahoma State University, Department of Biology; [3]Tufts University, Department of Biology. Glucocorticoids (GCs), or stress hormones, increase in animals after exposure to stressors and enable organisms to meet energy requirements by increasing metabolic activity (e.g. protein catabolism and gluconeogensis). Increases in metabolism should translate to increases in whole animal metabolism, and therefore energy expenditures by organisms. Few studies have examined the effects of GCs on energy expenditure and have produced conflicting results, which could be attributable to species-specific differences, differences in methodology and the levels of GCs examined (physiological vs. pharmacological). We examined the effects of exogenous administration of corticosterone (CORT), the primary GC in reptiles, on metabolism in western fence lizards (*Sceloporous occidentalis*) by frequently measuring changes in respiration for 48 hours after dosing. Low levels of CORT resulted in plasma CORT concentrations similar to controls, however injections of 0.40µg/g body weight of CORT produced a ten-fold increase in plasma CORT concentrations 3 hrs post

dose. Interestingly, increases in respiration were also noted in the highest dose group during this time interval. Respiration rates were returning to baseline 6 hours after dosing which coincided with decreases in plasma CORT concentrations. Our results suggest that frequent measures of metabolism facilitate detection of subtle and dynamic changes in respiration caused by GCs that may be important for understanding the overall energetic implications of stress.

EFFECT OF CENTRAL NEUROTENSIN ON APPETITE IN 4-DAY POST-HATCH CHICKS. Wint Nandar & Mark Cline, Neurophysiology & Behavior Lab, Dept. of Biol., Radford Univ., Radford, VA 24142. Neurotensin, a 13-amino acid peptide, was first isolated from the bovine hypothalamus and later was identified in the intestinal tracts of mammals and chickens. Intracerebroventricular or intraperitoneal injection of neurotensin suppresses food intake in rats. It also regulates the digestion and gastric motility in humans, dogs and guinea pigs. Intraperitoneal injection of neurotensin inhibits gastrointestinal motility in chickens. The biological role of central neurotensin in avians is unknown, thus we conducted an experiment to investigate the effect of central neurotensin on appetite in chicks. Four-day post-hatch chicks, *Gallus gallus*, randomly received intracerebroventricular injection of neurotensin (0, 15, 30 or 60 µg) and feed consumption was monitored for 90 minutes post injection. Our results demonstrated that central neurotensin caused a linear dose dependent decrease in feed intake from 15 min to 60 min post-injection in chicks. Neurotensin may regulate the appetite through both central and peripheral mechanisms.

EFFECTS OF AROCLOR 1254 ON UDP-GT ACTIVITY AND THYROID FUNCTION IN JAPANESE QUAIL. Catherine M. Webb & F. M. Anne McNabb, Department of Biological Sciences, Virginia Tech, Blacksburg, VA, 24061. Polychlorinated biphenyls (PCBs) decrease thyroid function in mammals as indicated by decreased circulating thyroxine (T_4). PCBs increase the excretion of T_4 by two mechanisms: (1) induction of uridine diphosphate-glucuronosyltransferase (UDP-GT), a liver enzyme that glucuronidates T_4, and (2) displacement of T_4 from transthyretin, a thyroid hormone binding protein in the blood, creating free T_4. There are many studies in which rats or mice were exposed to a mixture of PCBs, Aroclor 1254, and it was found that UDP-GT activity toward T_4 was increased, and circulating T_4 concentrations were decreased. Compared to mammals, there have been relatively few such studies in birds. In the present study, Japanese quail were exposed to vehicle or 500 mg/kg body weight Aroclor 1254 for 5 or 21 days. UDP-GT activity was increased significantly compared to controls at both exposure times. Plasma T_4 concentrations tended to decrease, but not significantly. Thyroid gland T_4 content was not altered. This was the first study to demonstrate induction of UDP-GT activity toward T_4 in quail. We conclude that the dose of Aroclor 1254 was not large enough to cause decreased thyroid gland T_4 content or decreased plasma T_4 concentrations, and that we would see significant decreases if the dose were increased. (Supported by a Virginia Tech Graduate Research Development Project grant.)

CENTRAL AMYLIN INCREASES WHILE ENTEROSTATIN DECREASES FEED INTAKE IN LARGE MOUTH BASS. Marissa L. Smith and Mark A. Cline, Department of Biology, Radford University, Radford, VA 24142. Amylin, a 37-residue peptide, and enterostatin, a 5-residue peptide, are secreted from the pancreas and affect ingestive-related processes in mammals. The effects of amylin and enterostatin in carnivorous fish are unknown; therefore, we conducted the following experiments using large mouth bass. Juvenile fish were injected with 0, 12.5, 25, or 50 micrograms rat amylin (Exp 1) or 0, 1, 10 or 100 micrograms human enterostatin (Exp 2) into the third ventricle using a modified free-hand technique. Amylin-treated large mouth bass responded with increased feed intake, which is similar to the effect we previously observed after injecting rat amylin in goldfish. However, when amylin is centrally administered to various mammalian species a reduction in feed intake is reported. Enterostatin-treated large mouth bass responded with decreased feed intake. This effect is similar to that reported in mammals. These results support evolutionary differences between fish and mammals for the amylin- and similarities for the enterostatin-gut-brain axes. Additional research is warranted to better understand the biological reason for these differences.

NOCTURNAL THERMOREGULATION IN THE AMERICAN ROBIN, *TURDUS MIGRATORIUS*, DURING WINTER. Raiza Vega-Candelario, Dept. Biological Sci., Univ. of Mary Washington, Fredericksburg, VA 22401. Thermoregulation is a costly biological activity for endotherms such as birds, especially when food is limited and temperatures are cold. When non-energy requiring heat conservation mechanisms are not adequate, birds may use facultative hypothermic responses. Although shallow rest-phase hypothermia has been identified in passerines, most research has been conducted in laboratories under controlled conditions. However, little is known about nocturnal thermoregulation in free-range passerines. One such passerine is the American Robin. I measured skin temperatures of five free-ranging American Robins between 1400-1500 and 0200 and 0300 hours for three to seven 24-hr cycles per subject. Nighttime ambient temperatures ranged from -4°C to 16°C during the study period. For all pooled observations (n = 40), skin temperature reductions ranged from 2.5°C to 6.4°C, while the average nightly skin temperature reduction per individual was 3.1°C. To our knowledge, these data represent the first evidence of facultative rest-phase hypothermia in a free-ranging member of the thrush family.

A STUDY OF THE PROTEOME OF THE APICAL SEGMENT MEMBRANES OF GUINEA PIG SPERMATOZOA. Sara S. Hirsch & James A. Foster, Dept. of Biol. Randolph-Macon Coll., Ashland VA 20005. The membranes over the acrosome play a key role in sperm-egg zona pellucida interactions in mammals, but few of the integral membrane proteins there have been characterized. The apical segment (AS) of guinea pig sperm, containing the plasma and outer acrosomal membranes along with the acrosomal matrix, can be isolated in sufficient quantities to perform biochemical analysis. . Following the isolation of apical segments, AS proteins were separated into aqueous and detergent phase proteins by Triton X-114

phase partitioning. SDS-PAGE zymography detected acrosin activity concentrated in the aqueous phase with some partitioning into the detergent. Additionally, western blot analysis showed that the acrosomal matrix proteins SP-10 and AM50 partitioned mostly into the aqueous phase with a small amount resolving in the detergent phase. Thus, several known acrosomal matrix proteins appear to have some association with the membranes. One-dimensional SDS-PAGE analysis demonstrated that there are clear differences between the protein contents of the aqueous and detergent phases and identified a set of putative membrane-associated proteins. Proteomic analysis of 14 prominent detergent phase bands identified several proteins known to be associated with the AS membranes as well as many that have not yet been identified in mammalian sperm, including several adhesion proteins, numerous vesicle-associated proteins and signaling proteins, and two G-protein coupled receptors. Funded by a Virginia Academy of Science Undergraduate Research Grant to SH and a Small Project Research Grant to JF.

THE INFLUENCE OF EASTERN HEMLOCK, *TSUGA CANADENSIS*, ON ORGANIC MATTER AND NUTRIENT DYNAMICS IN HEADWATER STREAMS. Kate Morkeski, Julie E. Frank, Jackson R. Webster, & E. F. Benfield, Dept. of Biol. Sci., Va. Polytechnic Inst. & State Univ., Blacksburg, VA 24061. In the southern Appalachians, eastern hemlock is the only conifer that commonly occurs along streams, and it is currently experiencing widespread mortality due to an introduced insect. We added hemlock sticks to one headwater stream and hardwood twigs to another to determine whether the finely branched structure and decay resistance of hemlock twigs make them particularly effective contributors to leaf retention and thus to nutrient uptake. Ammonium demand in the two streams showed a strong seasonal pattern, rising with autumn leaf fall and decreasing as leaves were eliminated, but showed no apparent effects of twigs. Organic matter standing stocks, leaf transport distance, and hydraulic characteristics of the two streams have yet to be determined. Stream incubations showed that hemlock twigs support lower rates of microbial respiration and less fungal biomass and have lower breakdown rates than birch twigs, suggesting that the elimination of hemlock trees will result in the loss of a recalcitrant organic matter source to headwater streams. Retention of leaves by hemlock or hardwood twigs appears to be less important than other factors in regulating ammonium uptake, but the removal of long-lasting hemlock twigs may subtly alter structural characteristics and microbial activity in headwater streams.

THE TVN0703 PROTEIN FROM *THERMOPLASMA VOLCANIUM*, A PROBABLE ARCHAEAL METAL-DEPENDENT SERINE/THREONINE PROTEIN PHOSPHATASE (PPM). AbdulShakur H. Abdullah, Dept. of Biochem., Virginia Polytechnic Institute and State University, Blacksburg, VA. 24060. In order to survive and flourish, living organisms must sense and react to changes in their internal and external environments. Two major classes of potential cellular responses to environmental change are: alterations in gene expression and modifications to existing proteins. Changes in gene expression are generally caused by activation or repression of transcription, which is a slow response (minutes to

hours). Modifications to existing proteins are typically mediated by enzymes and constitute fast responses (seconds to minutes). Protein phosphorylation-dephosphorylation represents one of nature's major mechanisms for regulating protein function. The dawn of genome sequencing has created an opportunity to utilize phylogenetic diversity as a resource for exploring the similarities in the phosphorylation/dephosphorylation mechanisms of different organisms, including parallels between relatively simple organisms and more complex organisms that are generally more difficult to study. Most archaeal genomes encode potential protein kinases and protein phosphatases. However, unlike other archae, we have found that *T. volcanium* has a potential PPM protein phosphatase based on DNA-derived amino acid sequence that thus far shows a kinetic profile similar to known PPMs. In addition, we have shown zinc to be a potent inhibitor of the *T. volcanium* PPM in vitro. This opens the way to ask whether zinc may be a physiological inhibitor of the *T. volcanium* PPM in vivo since zinc plays a role in the stress response in eukaryotes by inhibition of PPM.

ARABIDOPSIS THALIANA *MYO*-INOSITOL PHOSPHATE SYNTHASE MUTANTS VARY IN THEIR RESPONSES TO ABIOTIC STRESSES. Pyae P. Hein, Javad Torabinejad, & Glenda E. Gillaspy, Dept. of Biochem., Va. Polytechnic Inst. & State Univ., Blacksburg VA 24061. The *myo*-inositol metabolic pathway produces substrates for the synthesis of second messengers in plant cells. Second messengers are molecules that organisms use to communicate with their neighbors and respond to other biotic and abiotic stress stimuli. *Myo*-inositol phosphate synthase (MIPS) is the rate limiting enzyme in the *myo*-inositol metabolic pathway and three genes (MIPS1, MIPS2, and MIPS3) encode MIPS enzyme in the model plant, *Arabidopsis thaliana*. Loss of function MIPS-1, MIPS-2, and MIPS-3 *Arabidopsis* mutants were previously isolated and are useful in addressing the importance of MIPS in plants. We hypothesized that the *mips* mutants, compared to the wild type plants, differ in their responses to various stresses that may use inositol-containing second messengers. To test the hypothesis, we analyzed the responses of *mips1*, *mips2*, and *mips3* mutants to salt, abscisic acid, sorbitol, and lithium. We measured the seedling responses to these stresses by evaluating seed germination and root elongation. The analysis of transgenic seedlings revealed that *mips1* mutants were the most sensitive to most of the stresses tested. In contrast, *mips-2* and *mips-3* mutants were similar to wild-type seedlings in their responses to these stresses. These results suggest that the MIPS1 gene plays an important and unique role in synthesizing substrates for second messengers used during the stress response in plants.

CHARACTERIZATION OF TWO ARABIDOPSIS BETA-GALACTOSIDASES. Dashzeveg Gantulga[1], Y. Turan[1], B. S. Winkel[1], D. R. Bevan[2], and A.Esen[1]. [1]Department of Biological Science, Virginia Polytechnic Institute and State University and [2]Biochemistry Department, Virginia Polytechnic Institute and State University, Blacksburg, VA, 24061. The *Arabidopsis thaliana* genes At1g45130 and At3g52840 encode β-galactosidase isozymes Gal-5 and Gal-2, respectively. Microarray data analysis (Genevestigator tool) shows the highest expression of

At1g45130 in stem node and root elongation zones while that of At3g52840 in the petiole of adult leaves. These two isozymes share 38-81% sequence identity with other plant β-galactosidases, which are believed to be involved in modification of cell wall polysaccharides. Phylogenetic analysis reveals that Gal-5 and Gal-2 belong to the glycosyl hydrolase (GH) family 35, which includes most plant β-galactosidases. Recombinant Gal-5 and Gal-2 were expressed in *Pichia pastoris* and purified to electrophoretic homogeneity. Both enzymes hydrolyze such artificial beta-galactosides as *p*NPGal, *o*NPGal, 4-MUGal, X-Gal and 6-BNGal at a pH optimum of 4.0-4.5. This acidic pH optimum for enzyme activity is similar to the pH optimum of other characterized plant β-galactosidases and cell wall hydrolases. Gal-5 and Gal-2 exhibit highest specificity for the galactose moiety of substrates followed by fucose among five different glycosides tested. In addition, both isozymes cleave β(1-4) and β(1-3) linkages of galacto-oligosaccharides and release free D-galactose.

THE COMPLETE MITOCHONDRIAL GENOME OF *OLIGOCLADO FLORIDANUS*: IMPLICATIONS FOR PLATYHELMINTH PHYLOGENY. Nitin Bhagi, Virginia Commonwealth University, Richmond VA 23220. Platyhelminthes, or flatworms, are a very diverse group of simple invertebrate animals that despite their varying differences have been classified into two major taxa, the Acoelomorpha and the Rhabditophora. The Rhabditophora taxon is further divided into three general classes including Trematoda, Cestoda, and Turbellaria. The class Turbellaria, in particular, contains a wide range of flatworms that are not easily classified into any of the other two classes and hence there is some inconsistency within the current Platyhelminth classification system. Therefore, phylogenetic analysis based on mitochondrial gene order, can be used to correctly define how closely related two or more species are, despite what their current strict taxonomy indicates. Consequently, in this experiment the mitochondrial gene order of *Oligoclado floridanus* was determined using ten specific sequencing primers so that this species could be compared to the flatworms that have their mitochondrial gene order already determined and published. Finally, a preliminary phylogenetic tree was constructed from the data obtained using a parsimony analysis of the gene relative positions, which helps to validate the usefulness of gene order comparisons for phylogenetic reconstruction.

MAPPING OF BGAF BINDING REGIONS ON THE MAIZE b-GLUCOSIDASE ISOZYME GLU1. H. Y. Yu[1], F. Kittur[1], D. R. Bevan[2], and A. Esen[1], [1]Dept. of Biological Science and [2]Dept. of Biochemistry, Virginia Polytechnic Institute and State Univ., Blacksburg, VA 24061. In maize, two β-glucosidase isozymes (Glu1 and Glu2) have been identified and studied with respect to structure and function. In null maize genotypes, β-glucosidase fails to enter the gel and cannot be detected on zymograms. A specific β-glucosidase aggregating factor (BGAF) is responsible for the "null" phenotype. Domain swapping between maize β-glucosidase isozymes Glu1 and Glu2, to which BGAF binds and sorghum β-glucosidase (dhurrinase) isozyme Dhr1, to which BGAF does not bind, suggested that an N- terminal region (Glu50-Val145) and an extreme C-terminal region (Phe466-Ala512) together form

the BGAF binding site. We swapped the N-terminal (Ile72-Thr82) and C-terminal (Phe466-Ala512) regions of Glu1 with those of Dhr1. The results of binding assays suggest that the amino acids essential for BGAF binding are located in the N-terminal region (Ile72–Thr82) whereas the C-terminal region plays only a minor role. To identify the specific amino acids involved, we mutated the unique amino acids in the N-terminal region of Glu1 (Ile72/Val73, Asn75/Asp76, Lys81/Ala82, and Thr82/Glu83) to those in Dhr1. Of these single amino acid substitutions, the replacement of Thr82 in Glu1 with the corresponding residue (Glu83) in Dhr1 completely abolished binding to BGAF, suggesting that Thr82 plays a critical role in BGAF binding. This research is supported by Grant MCB-0417342 from the National Science Foundation.

PRE-FRACTIONATION BY LIQUID ISOELECTRIC FOCUSING OF THE *PENICILLIUM MARNEFFEI* SECRETOME. Kara G Segna[1], Tim D. Kim[2], Chet R. Cooper[2] & Gary R. Walker[2], [1]Christopher Newport University, Newport News VA 23606, [2]Youngstown State University, Youngstown OH, 44555. The fungal pathogen *Penicillium marneffei* is a significant opportunistic infection in Southeast Asia among immuno-compromised individuals. Although it is related to other *Penicillium* species, *P. marneffei* shows dimorphism unique to its genus. At 25°C, *P. marneffei* grows as a monomorphic mold, exhibiting the characteristics of other members of its genus. However at 37°C, *P. marneffei* grows in a yeast-like form, known as arthroconidium. The secretome of an organism comprises all proteins secreted into the surrounding environment. The yeast form of *P. marneffei* secretes different proteins than that of the mould form. We analyzed the secretome by means of 1 and 2 DGE electrophoresis after prefraction by liquid isoelectric focusing. An identification and understanding of these form-specific proteins will further our understanding of the pathogenic processes in this and other fungi.

UTILIZATION OF *SACCHAROMYCES CEREVISIAE* SCREENS TO ANALYZE TYPE-III SECRETED PROTEINS OF *SHIGELLA FLEXNERI*. Kumkum Sarkar, Virginia Commonwealth Univ., Richmond, VA 23284 & Cammie F. Lesser, Massachusetts General Hospital and Harvard Medical School, Cambridge, MA 02139. In the developing world today, diarrheal diseases like shigellosis continue to exist as an eminent problem, as they account for over 1 million deaths worldwide. *Shigella flexneri* uses a type-three secretion system to translocate toxic proteins, invade host cells, and spread intracellularly in the gut epithelium. The yeast screens were analyzed through non-inducing and inducing media to examine protein-protein interactions. It was hypothesized that through these genome-wide yeast screens, one will be able to further characterize the molecular roles of IcsB, IpgB2, and IpaJ in pathogenesis. After testing stock plates 104-150, 170, 171, and 172 using *Shigella* proteins IcsB, IpgB2, and IpaJ, the strains of yeast that showed growth in all four spots of yeast on inducing media were documented and retested on the 3 separate master plates that contained 26 yeast strains. IcsB had 10 hits in galactose, IpgB2 had 7 hits in galactose, and IpaJ had 3 hits in galactose. It was found that gal 3 and YJL051W suppressed all three proteins. Both IcsB and IpgB2 were suppressed by bud13 and sus1. Thus, *Saccharomyces cerevisiae* screens have been essential in modeling the interactions between eukaryotic cell proteins and

Shigella virulence proteins such as IcsB, IpgB2, and IpaJ. By utilizing yeast screens, one can study other pathogens like *Pseudomonas aeruginosa* in host cell environments as well. These studies can all lead to further knowledge in basic bacterial pathogenesis.

BOUNDRY EFFECTS UPON POPULATION DISTRIBUTION: THEOERTICAL MODE AND CASE STUDY. Steven A. Hand, N. Bly & L. Espinasa, Natural Sciences Dept., Shenandoah University, Winchester VA, 22601. This study investigated the effect of a major environmental boundary, the Grand Canyon in Arizona, on the population distribution of the locally dominant tree species. We found that both transect studies and satellite images showed reduced tree population density in the proximity of the canyon edge. We explored the environment-tree system dynamics using a computational model incorporating coupled multi-generational dynamics, locally variable environmental carrying capacity, and a porous seed dispersal barrier. The model demonstrated that diffusion of seeds in the vicinity of the canyon edge is sufficient to account for the observed population distribution independent of other environmental parameters. We believe our study has relevance for the introduction of artificial boundaries into established ecosystems and their potential impact upon established populations.

DISPERSION AND PLACEMENT OF PRAYING MANTID EGG CASES IN AN OLDFIELD. R. K. Rose & A. S. Bellows, Dept. of Biol. Sciences, Old Dominion Univ., Norfolk, Virginia 23529-0266. We studied the introduced Chinese praying mantis, *Tenodera aridifolia sinensis*, in an oldfield converting to a pine stand through secondary succession in Chesapeake, Virginia. In each 6.25 X 6.25 m sub-cell in our 1-ha grid, we recorded the number of egg cases (oöthecae), the plant species to which each egg case was attached, its height on the plant, its approximate compass orientation, and the estimated percent of open area with herbaceous vegetation. In winter/spring 2005, 586 egg cases were found in the 324 sub-cells (mean = 1.81). The highest mean (2.70) was found in sub-cells with 25% open/75% trees and lowest mean (0.40) was found in areas with few or no trees (100 % open). Forty percent of egg cases were oriented southward. To test the hypothesis that south-facing egg cases might hatch sooner, we collected 192 egg cases on January 28, 2006 in the same field, recording orientation on the plant (0-359°, using a compass). Egg cases were removed from their host plant, weighed, placed separately into quart mason jars in an 18 °C room, and examined daily until all young had hatched. Three egg cases yielded young on the third day, and another on the fourth, but regular hatching did not begin until day 32, after which one or more egg cases hatched almost daily until day 89. After placing into eight 45° orientation sectors, *Chi*-square analysis revealed a significant ($p < 0.001$) difference in egg case orientation, with large numbers facing south and southeast and many fewer than expected in the northern sectors. ANOVA revealed no significant differences among orientation sectors for days until hatching. We gratefully acknowledge The Nature Conservancy for the use of their land for our studies.

SPATIAL MODELING OF MOSQUITO HABITAT IN COASTAL PLAIN ENVIRONMENTS. A. S. Bellows[1,2], T.R. Allen, Jr.[2], & R. K. Rose[1], [1]Department of Biological Sciences & [2]Department of Political Science & Geography, Old Dominion University, Norfolk, VA 23529. We created a set of predictive, spatially explicit classification models capable of ranking suitable mosquito habitat in heterogeneous landscapes with an emphasis on vectors of West Nile Virus and eastern equine encephalitis and species that were particularly abundant. The study area was the City of Chesapeake, Virginia. Life-history processes dictate organismal distributions, and are a function of spatial land cover patterns (*i.e.*, land cover composition and configuration). Thus, we hypothesized that local mosquito abundance can be predicted from a parsimonious set of measurable environmental factors represented as thematic layers in a GIS. Layers represented soil (e.g., runoff potential, water capacity) and vegetation (i.e., Tasseled Cap transformations [TC]: wetness, greenness, brightness) characteristics. Soil moisture is closely associated with mosquito life histories and spatial composition and configuration of vegetation are closely linked with species diversity and abundance. TC has been useful for inferring photosynthetic activity and vegetative structure. All thematic layers were derived via direct interpretation of Landsat ETM+ imagery. Analyses included a comparison of the ability of linear regression models (parametric) and artificial neural networks (ANN: non parametric) to accurately predict habitat suitability and subsequent mosquito abundance. These HSIs were derived from spatially explicit empirical data, thus, making them useful within real landscapes. Future research will include metapopulation implications and subsequent spatial strategies of chemical mosquito control.

EFFECTS OF CELEBREX (CELECOXIB) ON THE FREQUENCY OF PREGNANCY LOSS INDUCED IN CD-1 MICE BY LIPOPOLYSACCHARIDE INJECTIONS. Kristin Cooper[1], Carolyn M. Conway[2], and Arthur F. Conway[1], [1]Dept. of Biology, Randolph-Macon Coll., Ashland, VA 23005 and [2]Dept. of Biology, Virginia Commonwealth Univ., Richmond, VA 23284. Lipopolysaccharide (LPS), a component of the outer membrane of the cell wall of Gram-negative bacteria, triggers pregnancy loss in mammals. General non-steroidal anti-inflammatory drugs as inhibitors of LPS-induced pregnancy loss have produced mixed results. A specific cyclooxegenase-2 inhibitor, Celebrex (celecoxib), was evaluated in this study. Pregnant CD-1 mice were given one of three doses of Celebrex (0, 18, 36 μg/ml) from day 7 to day 12 in drinking water and one of three dose of LPS (0, 2, 5 μg) by intravenous injection on day 9 of gestation. Pregnancy loss was evaluated by sacrifice on day 12 of gestation. LPS treatment significantly increased frequency of pregnancy loss, significantly reduced maternal body weight and significantly increased maternal spleen weight. The high dose of Celebrex (36 μg/ml) decreased pregnancy loss in some of the mice treated with 5 μg LPS, but the effect was neither consistent nor statistically significant. Celebrex treatment had no apparent effect on maternal body weight loss in response to LPS treatment, and very little effect on maternal spleen weight increase in response to LPS treatment. Thus, Celebrex appears to have limited, if any, use for prevention of pregnancy loss or control of inflammation resulting from Gram-negative infections during pregnancy.

EFFECTS OF DEXAMETHASONE ON THE FREQUENCY OF PREGNANCY LOSS INDUCED IN CD-1 MICE BY LIPOPOLYSACCHARIDE INJECTIONS. Jonathon Farmer[1], Carolyn M. Conway[2], and <u>Arthur F. Conway</u>[1], [1]Dept. of Biology, Randolph-Macon Coll., Ashland, VA 23005 and [2]Dept. of Biology, Virginia Commonwealth Univ., Richmond, VA 23284. Lipopolysaccharides (LPS) cause strong inflammatory responses and can cause pregnancy loss at low doses. We studied the effects of daily intraperitoneal injections of dexamethasone on frequency of LPS-induced pregnancy loss. Intravenous injection of two or five micrograms of LPS on day 9 of gestation significantly increased frequency of pregnancy loss, decreased weight of implantation sites, caused significant maternal weight loss, and slightly increased maternal spleen weight. Dexamethasone administered on days 8 through 11 inhibited all LPS effects, with the reduction in LPS-induced pregnancy loss being statistically significant. One hundred micrograms of dexamethasone per day was as effective as 200 micrograms in reducing LPS-induced maternal weight loss and was more effective that 200 micrograms in reducing LPS-induced pregnancy loss. Dexamethasone caused a statistically significantly dose dependent reduction on spleen weight independent of LPS treatment status.

EFFECTS OF INDOMETHACIN ON THE FREQUENCY OF PREGNANCY LOSS INDUCED IN CD-1 MICE BY LIPOPOLYSACCHARIDE INJECTIONS. Joseph Greenwood[1], Carolyn M. Conway[2], and <u>Arthur F. Conway</u>[1], [1]Dept. of Biology, Randolph-Macon Coll., Ashland, VA 23005 and [2]Dept. of Biology, Virginia Commonwealth Univ., Richmond, VA 23284. Lipopolysaccharides (LPS) cause strong inflammatory responses and can cause pregnancy loss at low doses. The effects of orally administered indomethacin on the frequency of lipopolysaccharide-induced pregnancy loss were studied in CD-1 mice. Indomethacin (0, 5, or 10 μg/ml) was administered in drinking water on days 7 through 12 of gestation and LPS injections (0, 2 or 5 μg) were given intravenously on day 9 of gestation. Mice were sacrificed on day 12 of gestation and examined for pregnancy loss. LPS induced pregnancy loss in a dose-dependent pattern. The indomethacin treatments tested had no effect on the frequency of LPS-induced pregnancy loss. These results indicate either that LPS-induced pregnancy loss does not depend on prostaglandin synthesis or other processes sensitive to indomethacin, or that orally administered indomethacin fails to achieve a concentration at critical locations which is sufficient to inhibit pregnancy loss.

EFFECTS OF PRETREATMENT WITH LIPOPOLYSACCHARIDE ON THE FREQUENCY OF PREGNANCY LOSS INDUCED IN CD-1 MICE BY LIPOPOLYSACCHARIDE INJECTIONS. <u>Daniel Hudgins</u>[1], Carolyn M. Conway[2], and Arthur F. Conway[1], [1]Dept. of Biology, Randolph-Macon Coll., Ashland, VA 23005 and [2]Dept. of Biology, Virginia Commonwealth Univ., Richmond, VA 23284. Lipopolysaccharides (LPS) cause strong inflammatory responses and can cause pregnancy loss at low doses. A report that exposure to a low dose of lipopolysaccharide (LPS) earlier in pregnancy reduced the frequency of pregnancy loss induced by exposure to a larger dose of LPS later in pregnancy was systematically evaluated. Treatment of mice not previously exposed to LPS with two or five micrograms of LPS intravenously on day 9 of gestation significantly

increased pregnancy loss in a dose-dependent pattern. Intraperitoneal injections of LPS on day 7 followed by intravenous LPS on day 9 resulted in less pregnancy loss than resulted from the day 9 treatment alone. Maternal bodyweight was reduced in a dose-dependent pattern as LPS was increased but all mice showed a decrease in weight associated with handling stresses. As day 7 LPS dose was increased, implant weight was reduced relative to PBS-treated mice, indicating growth retardation in surviving implantation sites. Granulocyte abundance in the mesometrial region and total peroxidase staining (index of tissue destruction) at the placental margins were not correlated with frequency of pregnancy loss. If repeatable, these results argue very strongly against either of these patterns being heavily involved in pregnancy loss.

EFFECTS OF SINGULAIR (MONTELUKAST) ON THE FREQUENCY OF PREGNANCY LOSS INDUCED IN CD-1 MICE BY LIPOPOLYSACCHARIDE INJECTIONS. Roberta Monnier[1], Carolyn M. Conway[2], and <u>Arthur F. Conway</u>[1], [1]Dept. of Biology, Randolph-Macon Coll., Ashland, VA 23005 and [2]Dept. of Biology, Virginia Commonwealth Univ., Richmond, VA 23284. Lipopolysaccharide (LPS) is a Gram-negative bacterial cell wall component that causes a strong inflammatory response and can cause pregnancy loss at low doses. A major component of inflammatory responses involves prostaglandin and leukotriene secretion. General non-steroidal anti-inflammatory drugs (NSAIDs) which block the cyclooxygenase enzymes involved in prostaglandin synthesis have been used as inhibitors of LPS-induced pregnancy loss with mixed results. This study examined the effect of Singulair on LPS-induced pregnancy loss in CD-1 mice. Singulair specifically blocks the action of leukotrienes, another cause of inflammation. Three doses of Singulair (0 μg/ml, 1 μg/ml or 2 μg/ml) were given to mice in drinking water on gestation days 7-12. Mice also received 0, 2 or 5 μg LPS in tail vein injections on day 9 of gestation. Two μg/ml Singulair resulted in a slight reduction in the pregnancy loss induced by LPS, but the effect was not statistically significant. Spleen weight increased slightly with increased Singulair dose, but the effects were not statistically significant. Singulair treatment had no statistically significant effects on the reduced implantation site weight induced by LPS. The partial inhibition of LPS-induced pregnancy loss by Singulair indicates that leukotrienes are probably involved but are apparently not the primary mechanism of pregnancy loss.

EFFECTS OF VITAMIN C (ASCORBIC ACID) ON THE FREQUENCY OF PREGNANCY LOSS INDUCED IN CD-1 MICE BY LIPOPOLYSACCHARIDE INJECTIONS. Inger Reres[1], Carolyn M. Conway[2], and <u>Arthur F. Conway</u>[1], [1]Dept. of Biology, Randolph-Macon Coll., Ashland, VA 23005 and [2]Dept. of Biology, Virginia Commonwealth Univ., Richmond, VA 23284. Lipopolysaccharides (LPS) cause strong inflammatory responses and can cause pregnancy loss at low doses. We studied the effects of oral and intraperitoneal administration of ascorbic acid on frequency of LPS-induced pregnancy loss. Intravenous injection of two or five micrograms of LPS on day 9 of gestation significantly increased frequency of pregnancy loss, decreased weight of implantation sites, and caused significant maternal weight loss. Oral administration of 15 mg ascorbic acid per day in

drinking water resulted in no changes in any of the LPS effects. Intraperitoneal injection of 15 milligrams of ascorbic acid 45 minutes prior to the LPS injection significantly inhibited LPS-induced pregnancy loss and maternal weight loss and increased implantation site weights. Intraperitoneal injection was clearly more effective than oral administration of ascorbic acid, but we are unsure of the reasons.

THE EFFECTS OF ELECTROMAGNETIC FIELDS ON MOUSE BRAINS AND BEHAVIOR. Katherine M. Farrell & Deborah A. O'Dell. Dept. of Biological Sciences, Univ. Mary Washington, Fredericksburg, VA 22401. Enzymes in the melatonin biosynthetic pathway are inhibited by applied magnetic fields resulting in a decrease of melatonin. Tryptophan hydroxylase (TPH) is an enzyme important in melatonin biosynthesis and can be measured to indirectly observe melatonin levels. The purpose of this experiment was to investigate the effects of magnetic fields on tryptophan hydroxylase levels in the mouse brain and on mouse behavior. Two experimental groups, exposed to different magnetic field strengths (+0.5G & +0.75G), and one control group were tested over a 12 week experiment. Experimental groups showed a decrease in the area of TPH positive cells in the pineal gland and in TPH levels in blood serum and homogenized brain samples over time. Activity levels among experimental groups increased, while feeding habits decreased. These results support the hypothesis that exposure to magnetic fields leads to a decrease in melatonin levels, with longer exposure and stronger magnetic fields having a greater effect. This work was supported by an Undergraduate Research Grant from University of Mary Washington.

THE IMPORTANCE OF HEMLOCK WOOD INPUT INTO STREAM ECOSYSTEMS. Julie E. Frank, K. Morkeski, J.R. Webster, & E.F. Benfield, Dept. of Biological Sciences, Va. Polytechnic Inst. & State Univ., Blacksburg, VA 24061. Eastern hemlocks (*Tsuga canadensis*) are being rapidly killed by an insect, the hemlock woolly adelgid (*Adelges tsugae*). This insect infests hemlock trees and feeds on xylem ray parenchyma cells of the needles. The death of hemlock will lead to the growth of species such as black birch (*Betula lenta*) in riparian forests previously dominated by hemlock. Forested streams are influenced by inputs from hemlocks because this is the only riparian conifer in the southern Appalachians and it has been suggested that the decay resistance of hemlock wood makes it a critical structural component of streams. To explore the impacts of hemlock death, bundles of hemlock and birch twigs were placed in two small streams at Coweeta Hydrologic Laboratory in the southern Appalachian Mountains in North Carolina. Bundles were collected approximately monthly from October 2005 through April 2006 and used to measure breakdown rates and fungal biomass. For most of the study, fungal biomass was not significantly different between the two types of twigs; however, fungal biomass was significantly higher on birch twigs for collections from March through April. Also, breakdown rates of birch twigs were higher than breakdown rates of hemlock twigs. Based on this study, the widespread mortality of hemlock trees will result in the loss of critical physical structures, which are known to have a significant role in nutrient cycling, retention of organic matter, and in providing invertebrate habitat in headwater streams.

BACTERIAL COMMUNITY PROFILES AT ENVIRONMENTAL SITES CONTAMINATED WITH HEAVY METALS FROM MINING OPERATIONS. Julie Brooks, Katelyn Christopher, Shanley Ignacio, Tarah Brown, & Georgia Hammond, Department of Biology, Radford University, Radford, VA 24142. Microorganisms, due to their unique metabolic properties, play significant and key roles in remediation of polluted environments. The purpose of our project was to develop molecular profiles of bacterial communities present in sediments from abandoned mines contaminated with heavy metals. Using a culture-free method of acquiring DNA, we generate PCR products that correspond to a specific genetic region (from the ribosomal RNA cassette) from each of the bacteria present in the community sampled. The DNA products generated are variable in both length and nucleotide sequence. Agarose gel electrophoresis of the amplified DNA yields a ladder of fragments that constitutes a bacterial profile or fingerprint for each sediment sample. Profiles from samples allow us to compare bacterial communities, and to track changes in the communities over time. These data can be correlated with changes in communities of other organisms, or physical characteristics of the environment such as concentration of the heavy metals present, to yield a comprehensive view of remediation at our study sites.

EFFECT OF DIETARY WHEY PROTEIN SUPPLEMENTATION ON GROWTH OF *EUBLEPHARIS MACULARIS* (LEOPARD GECKOS). Breanna Hargbol, Adrienne Betancourt, Tommy Camp & Nick Snyder, Neurophysiology & Behavior Lab, Dept. of Biol., Radford Univ., Radford, VA 24142. We conducted an experiment to determine if supplemental dietary protein via gavage would accelerate the growth rate of leopard geckos. Geckos, 12 weeks of age, were randomly assigned to receive either 0 or 120 mg whey protein administered by gavage. Treatments were administered every other day with tap water serving as a vehicle. All geckos had *ad libitum* access to crickets, a calcium supplement, and water during the experiment. Daily body weights were recorded. Geckos treated with 120 mg whey protein responded with increased body weight 17 days following the start of treatment. Although the data collection ceased after 23 days, we propose that the magnitude of differential body weight would increase at day 24 and beyond. Thus, supplementing a leopard gecko's diet with whey protein is an effective method to accelerate body weight gain. This technique may be used by commercial reptile supply companies to increase production efficiency.

RNAI AND TRANSPOSABLE ELEMENT ACTIVITY IN *AEDES AEGYPTI*. Edward A. Mead & Zhijian J. Tu, Department of Biochem., Va. Polytechnic Inst. & State Univ., Blacksburg, VA 24061. Transposable elements make up a significant portion of the genome of most animals, and active transposable elements have demonstrated promise as vectors for genetic engineering. Transposition is often a rare event, making it difficult to identify currently active transposable elements. It has been shown in *C. elegans* and other systems that transposition is suppressed through several routes, including RNA interference. We have begun to target components of the siRNA pathway by transfecting mosquito cell lines with dsRNA against particular RNAi pathway components to remove the RNAi-mediated suppression of transposable elements. We have observed success with an

Argonaute-2 dsRNA knockdown of RNA interference, monitored through the use of a luciferase assay. We will monitor the change in transposable element activity by microarray and by examining the expression of rasiRNA. Successfully identified active transposable elements may then be used as vectors for introducing refractory genes into mosquitoes as a means to combat deadly epidemics such as malaria, West Nile, and dengue fever.

EFFECTS OF CENTRAL NEUROTENSIN ON BEHAVIOR AND ALIMENTARY CANAL TRANSIT TIME IN BROILER CHICKS. M. Meissner, M. Smith, W. Nandar & M. Cline, Department of Biology, Radford University, VA 24142. Neurotensin (NT), a 13 amino acid peptide, has been identified in the bovine hypothalamus and the intestinal tract of bovines, rats, and chickens. Central NT inhibits feed intake, affects uterine contraction, and causes duodenum relaxation in rats and ileum contraction in guinea pigs. The role of NT in chickens is unknown, thus we conducted experiments to determine the effect of NT on behavior and alimentary canal transit time in broiler chicks. In Experiment 1, chicks received central injections of NT and were placed in an observation arena. The chick's behavior was videorecorded for 15 min and later analyzed in 5 min intervals. The distance the chick traveled, the number of pecks, jumps, and escape attempts, and the amount of time the chick spent standing, sitting, preening, and sleeping were quantified. In Experiment 2, chicks received central injections of NT, followed by gavage of a known amount of chicken feed slurry. Gastric transit time was determined as the time post injection at which the marker was visually detected in feces. Our results demonstrated that central NT affected the total distance the chick traveled, but had no affect on total alimentary canal transit time in broiler chicks.

A COMPARISON OF THE NEUROANATOMY OF EGG-LAYING WORKERS OF *APIS CERANA* AND *APIS MELLIFERA*. Elena M. Quintiliani & Deborah A. O'Dell, Dept. of Biological Sciences, Univ. of Mary Washington, Fredericksburg, VA 22401. Egg-laying in female worker honeybees is suppressed by pheromones from the queen bee. In the absence of this suppression, workers show ovariole development and begin to lay eggs. Egg-laying *Apis mellifera* workers show an increase in size due to process growth within the ganglia controlling egg-laying compared to non-laying workers. This suggests that additional neuronal development must occur prior to egg-laying. The rate at which egg-laying begins after removal of suppression varies with different races of honeybees which suggests that some races may have more developed ganglia. Compared with the European honeybee (*Apis mellifera*), the Asian honeybee (*Apis cerana*) has a more rapid on-set of egg-laying behavior. We examined whether growth occurred in the abdominal ganglia of egg-laying workers of *Apis cerana*. A6 ganglia of *A. cerana* were measured in laying and non-laying workers and the sizes compared. Results show that in laying *A.cerana*, only an increase in ganglion length (26% increase) is seen, as compared to the A6 ganglia of laying *A. mellifera* in which an increase in both width (39%) and length (22%) is seen. This suggests that *A. cerana* has a more completely developed nervous system than *A. mellifera* although neuronal growth could not be assayed. This work was supported by an Undergraduate

CHRONIC EXPOSURE TO ENDOSULFAN ALTERS BEHAVIORAL PATTERNS IN WOOD FROG (*RANA SYLVATICA*) TADPOLES. Amanda K. Simmons, Jamie M. Leonard & Melissa Zwick, Department of Natural Sciences, Longwood University, Farmville, VA 23909. Endosulfan is an organochlorine insecticide used in agricultural systems to control a wide variety of insect pests. Endosulfan exerts neurotoxic effects by targeting both cholinergic and GABAergic systems. Non-target aquatic organisms, such as amphibians, are particularly susceptible to endosulfan exposure via runoff from agricultural fields following application of the pesticide. The effects of endosulfan on wood frog (*Rana sylvatica*) phenotype were explored by exposing *R. sylvatica* to either 10 µg/l or 20 µg/l endosulfan, acetone (vehicle control), or water (control) beginning in the egg stage and extending into the larval stage. Tadpoles exposed to endosulfan were significantly more active than control animals, but there was no difference in tadpole activity level in the two endosulfan treatments. There were no main effects of treatment on time to settle following a disturbance; however, there was a significant time by treatment interaction. This indicates a differential response between treatments over time. Following pesticide removal at day 7, behavior of tadpoles in endosulfan treatments began to resemble tadpole behavior in acetone and water treatment groups. Tadpoles exposed to endosulfan did not develop as rapidly as those in acetone and water treatments as measured by Gosner stage. These results clearly indicate that endosulfan alters the behavior of non-target organisms at environmentally realistic concentrations, possibly by affecting the development of the sensory and/or motor nervous systems.

IMPACTS OF AGRICULTURAL PESTICIDES ON THE SURVIVAL, GROWTH AND DEVELOPMENT OF THE WOOD FROG (*RANA SYLVATICA*). Allison M. Smith, Philip C. Klineburger, Ellen M. Simpson, Krystal L. Freels, Amanda K. Simmons, Jamie M. Leonard & Melissa Zwick, Department of Natural Sciences, Longwood University, Farmville, VA 23909. Global amphibian populations are currently experiencing significant decline and agricultural pesticides in aquatic ecosystems are likely one of the causative factors. Amphibians are often exposed to a combination of agricultural insecticides and herbicides during critical developmental stages. Endosulfan is an organocholorine insecticide that inhibits acetylcholinesterase and GABAergic systems and atrazine is a powerful herbicide used to control weeds by inhibiting photosynthesis. The effects of endosulfan and atrazine on wood frog (*Rana sylvatica*) phenotype were explored by exposing *R. sylvatica* to either 10 µg/l endosulfan, 20 µg/l atrazine, 10 µg/l endosulfan and 20 µg/l atrazine, or water (control) in the larval stage. Endosulfan had significant negative effects on wood frog tadpoles. Tadpoles were underdeveloped, weighed less, and experienced higher mortality when exposed to endosulfan, relative to tadpoles exposed to atrazine or water. Activity levels in *R. sylvatica* tadpoles were lower in endosulfan-treated tanks. Following both internal and external disturbances, tadpoles took longer to settle in tanks treated with endosulfan. Atrazine had no effect on any variables tested, and there were no interactive effects

of atrazine and endosulfan. These findings are consistent with previous research on the effects of pesticides on amphibian populations and future studies will explore the underlying neuroanatomy of tadpoles exposed to pesticides.

EFFECTS OF AMMONIUM PERCHLORATE ON THYROID FUNCTION AND PLASMA CORTICOSTERONE IN JAPANESE QUAIL. Eric R. Weigel, F. M. Anne McNabb, & Ignacio T. Moore, Dept. of Biol., Va. Polytechnic Inst. & State Univ., Blacksburg, VA 24061. Ingestion of perchlorate has been shown to inhibit the thyroid gland's production of thyroid hormones, tri-iodothyronine (T3) and thyroxine (T4) in various species. In this experiment, the effects of varying doses of ammonium perchlorate (AP) upon thyroid function and plasma corticosterone were investigated. Forty adult birds were separated into six experimental groups, with equal numbers of males and females. The groups received the followed doses of dissolved AP in their drinking water: 0 (control), 100, 250, 500, 1000, and 2000 mg AP/L of drinking water. Treatment was administered for 2 weeks, after which blood samples were taken, birds were sacrificed, and thyroid glands were removed. Thyroid function was assessed by T4 and T3 concentrations in the thyroid glands, T4 levels in plasma, and thyroid gland masses. Dose-dependent effects were observed, but only in male animals. In males, thyroidal T4 declined with increasing AP treatment, and thyroid gland hypertrophy was also evident, as expected. However, females did not respond significantly to any level of AP treatment. We hypothesize that some of the AP ingested by females may be accumulating in their eggs, thereby decreasing their effective thyroidal dose as compared to males.

THE EFFECT OF ANTIOXIDANT VITAMINS AND NSAID DRUGS ON PLAQUE FORMATION IN ALZHEIMER'S DISEASE. Kristen M. Zach & Deborah A. O'Dell. Dept. of Biological sciences, Univ. Mary Washington, Fredericksburg, VA. 22401. Alzheimer's Disease (AD) is characterized by the deposition of neurofibrillary tangles (NFTs), neuritic plaques composed of β-amyloid, the release of inflammatory molecules such as TNF-α, and severe lipid peroxidation. Although the exact mechanism responsible for causing this cascade of events is unclear, it is clear that they are interrelated and act synergistically to cause neuronal death. Recent therapeutic strategies attempt to limit the neurotoxicitiy of oxidative and immune responses through the use of antioxidant vitamins and non-steroidal anti-inflammatory drugs (NSAIDs). To determine the efficacy of Cellect brand vitamins and Ibuprofen in performing this role, we fed mice predisposed to plaque development (J10, JAX), rodent chow supplemented with either vitamins, Ibuprofen, or both for either 4 or 7 months. Mice from two litters were sacrificed and their brains removed and analyzed for presence of inflammation (TNF-α) and β-amyloid protein. The level of TNF-α in mice treated with supplements for 7 months was much lower than that of the control (0.046 ng/mg tissue vs 5113.38 ng/mg tissue, respectively). Analysis using light microscopy revealed that mice treated with a combination of Ibuprofen and vitamins for 7 months had the least amount of β-amyloid protein in the brain. This study indicates that a long-term diet supplemented with both vitamins and NSAIDs may help prevent the onset of the hallmark pathologies associated with AD. This

work was supported by an Undergraduate Research Grant from the University of Mary Washington.

ASSESSMENT OF A NATURALLY OCCURRING FATTY ACID AS AN ANTIMICROBIAL PRODUCT. James R. Doherty, Gregory J. Sproull & Barbara B. Kreutzer, Dept. of Integrated Science and Technology, James Madison Univ., Harrisonburg, VA 22807. Naturally occurring antimicrobial compounds are often less expensive to produce and deemed safer by the public than synthetic pharmaceutical products. We assessed a fatty acid abundantly present in some commercially produced plants for its use as an antimicrobial product. Chemical properties of the compound were examined and effectiveness was tested against bacterial growth using two methods, a sensitivity disc experiment and a liquid culture experiment. We found the compound to be strongly inhibitory to *Staphylococcus epidermis* growth and to have multiple properties which make it useful as an antibacterial product.

INFECTION OF HEPATOCYTE AND NON-HEPATOCYTE CELLS BY *FRANCISELLA*. A.P. Belsches-Jablonski[1], S. Pylypko[2] & M.L. van Hoek[2], [1]Biol. Program, Lynchburg Coll., Lynchburg, VA 24501, [2]Dept. of Molecular and Microbiology, National Center for Biodefense and Infectious Diseases, George Mason Univ., Manassas, VA 20110. *Francisella tularensis* is a gram-negative, coccobacillus, aerobic organism and is considered a Category A bioweapon due to its potentially high infectivity and ease of transmission. The predominant modes of transmission include inhalation and intradermal inoculation. Both have been shown to initiate severe infection in mammals with as low as 10 bacilli when aerosolized. Once *F. tularensis* enters the host, it multiplies within phagocytes as well as in other cells including hepatocytes. Our hypothesis is that *F. tularensis* LVS, *F. tularensis novicida,* and *F. philomiragia* infect and subsequently cause apoptosis in hepatocytes leading to liver failure contributing to tularemia pathogenesis. Our data suggest that *F. tularensis* LVS, *F. tularensis novicida,* and *F. philomiragia* effectively adhere to and given time, invade and replicate intracellularly within TIB-73, J774A.1, and HEPG2 cells. We observed a greater abundance of recovered bacteria in both the adherence and invasion/replication assays in HEPG2 cells versus murine embryonic liver (TIB-73) and macrophage (J774A.1) cell lines, suggesting that the human hepatocyte cell line has greater uptake ability and therefore may be more prone to infection than other cell types. In addition, infection of J774 macrophage cells by *F. tularensis* LVS results in early phosphorylation events in several downstream signaling molecules involved in apoptosis and/or cell proliferation. This study was funded by the Commonwealth Health Research Board of Virginia.

BIOFILMS OF *FRANCISELLA* & MIXED BIOFILMS WITH AMOEBA. A. B. Verhoeven & M. L. van Hoek. Department of Molecular and Microbiology, National Center for Biodefense and Infectious Diseases, George Mason University, Manassas, VA 20110. *Francisella* are pleomorphic, gram negative coccobacilli bacteria that have a thin lipopolysaccharide capsule and have recently been found to have pili. We are exploring the interaction of *Francisella* species and amoeba (such

as *Acanthamoeba castellani*), and their role in biofilms. Establishing *Francisella* as a biofilm-forming organism may help to explain the historical findings of close association with water and water-dwelling mammals, and may point to one of the natural reservoirs of this organism. In order to begin to address this question we demonstrate that biofilms are formed by some subspecies of this genus. Biofilms were detected using the standard crystal violet staining assay. Preferences were noted for surfaces that were positively charged such as polyvinyl chloride (PVC). This might imply that organic material found in waterways could serve as surfaces for biofilm formation and that *Francisella* in the wild would exhibit biofilm formation instead of platonic conformation. We also co-cultured amoeba and *Francisella* and have shown that they form a mixed biofilm when grown together. This could imply a symbiotic relationship with amoeba in the functioning biofilm, whereby the release of nutrients from the amoeba increases biofilm formation by the bacteria and the amoeba feeds on the bacteria (including *Francisella*) in the biofilm.

THE CHARACTERIZATION OF OUTER MEMBRANE VESICLES PRODUCED BY *Francisella* SPECIES. D. Matrakas[1], V. N. Morozov[2], W. Zhou[3] & <u>M. L. van Hoek</u>[1], [1]Department of Molecular and Microbiology, [2]National Center for Biodefense and Infectious Diseases, [3]Center for Applied Proteomics and Molecular Medicine, George Mason University, Manassas, VA 20110. The phenomenon of outer membrane vesicle (OMV) production occurs in many Gram-negative bacteria. OMV production by the genus *Francisella*, a Gram-negative bacterium, has not been reported to date. This work demonstrated the presence of OMVs from *Francisella* and a preliminary characterization of these OMVs. The characterization was done by the use of atomic force microscopy (AFM) and transmission electron microscopy (TEM). AFM studies showed that the OMVs from *Francisella* species were within the range of 50-250nm in diameter, as described for other Gram-negative bacteria. In addition to this characterization, we tested the cytopathic and hemolytic effects of OMVs on cells. Western blots were performed to detect the presence of lipopolysaccharide (LPS) and outer membrane proteins on the surface of the OMVs. This research was partially supported by grant funding from the Virginia Academy of Science Small Project Research Fund.

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IDENTIFICATION OF THE EFFECTS OF LOCAL MUSCLE FATIGUE ON POSTURAL SWAY THROUGH WAVELET ANALYSIS. <u>Hong B. Zhang</u> & Maury Nussbaum, Dept. of Industrial and Systems Eng., Virginia Tech, Blacksburg VA 24061. Occupational falls result in nearly 13% of U.S. workplace fatalities. Among several identified contributing factors, loss of balance has been indicated as an important precipitating event. Localized muscle fatigue (LMF) has been demonstrated to compromise the postural control system, and is a suspected risk factor for falls via decreases in muscular control and proprioceptive ability. Here, fatigue was induced, through voluntary exertions, in the ankle, knee, torso, and shoulder of experimental participants, and the effects on postural control quantified

from observed sway during quiet erect stance (eyes closed). Certain frequency bands in sway data correspond to specific postural control mechanisms (i.e. proprioception and central processing). A new algorithm was developed to estimate the entropy in these bands. Specifically, a wavelet transform was applied to obtain the frequency domain characteristics of sway in both the AP and ML directions. Total power was determined in the bands associated with the two control mechanisms. Finally, Tsallis entropy was calculated for each band both pre- and post-fatigue. Reduced entropy was interpreted as a decrease in complexity, which was used in turn to infer a disruption to the associated control mechanism. Such effects were found for the proprioceptive control of ML sway resulting from ankle and torso fatigue, and central control of bilateral sway from fatigue at all joints. This method has potential future utility in that it can ascertain effects on control mechanisms without the need for more complex perturbation methods. This work was supported by NIOSH Grant #R01 OH007882.

AN AFFORDABLE VIBROTACTILE DISPLAY DEVICE FOR THE BLIND AND VISUALLY IMPAIRED. David Burch and Dianne Pawluk, Department of Biomedical Engineering, Virginia Commonwealth University, Richmond VA. Currently, there are several systems that display graphical information to the blind and visually impaired; however, these systems are often too expensive and/or cumbersome for practical use by most individuals. Thus, there is a need for an affordable display device capable of rendering graphical information through stimulation of working sensory systems. To further facilitate individuals, the device must be portable, as to enable them to use it in many different settings. However, to keep the scope of the device within reasonable limits, the primary goal will be to create a device for rendering charts, graphs, and blueprints to blind and visually impaired individuals. The device I developed utilizes photo-detectors to produce a signal corresponding to areas of low photonic reflectivity. This signal then triggers a vibratory motor, stimulating tactile receptors in the user. By combining this tactile sensation along with a sense of device position, the user receives haptic feedback relating to the position of lines and shaded areas on charts, graphs, and blueprints.

A FINITE ELEMENT EXAMINATION OF THE SACROPLASTY PROCEDURE. Dennis E. Anderson & John R. Cotton, Department of Engineering Science and Mechanics, Va. Polytechnic Inst. & State Univ., Blacksburg, VA 24061. A new procedure called sacroplasty has recently been used as a treatment for sacral insufficiency fractures. Sacroplasty, which is similar to the well established vertebroplasty procedure, consists of the injection of polymethylmethacrylate (PMMA) bone cement into the cancellous core of the sacrum. This stabilizes fractures in the bone and provides rapid pain relief for most patients. Finite element models of the upper pelvis, including the sacrum, were used to examine the mechanical effects of cement in the sacrum. The geometry and nonhomogeneous material properties of the models were based on computed tomography (CT) images of cadavers on which sacroplasties were performed. The effect of the cement was examined by comparing models with and without the cement present. Because the stiffness of PMMA cement is higher than that of bone, inclusion of the cement increased the overall model stiffness by 1 to 5%. In the

locations of the cement, the principal strains were reduced by 40 to 60%. Thus, the effect of cement injection on the sacrum is primarily localized. This indicates that sacroplasty may be able to treat sacral insufficiency fractures without significantly altering the stiffness of the whole sacrum. This is in contrast to studies of the vertebroplasty, where cement injections into a vertebral body have been found to increase the vertebral body stiffness by 50% or more.

CHANGES IN BALANCE WITH LOW BACK FATIGUE. B.S. Davidson, M.L. Madigan, & M.A. Nussbaum, Virginia Tech Wake Forest School of Biomedical Engineering and Sciences, Blacksburg VA 24060. The purpose of this investigation was to characterize changes in postural sway and postural control during quiet standing using joint kinematics. Twelve physically active males participated in the experiment. Body position and center of pressure (COP) data during quiet standing were collected for 30 seconds both before and after a lumbar extensor fatigue protocol. Posture in the anterior-posterior (AP) plane was described using mean center of mass (COM) and COP position and mean joint angles. Postural sway was described using standard deviation (SD) of COM and COP position, SD of ankle, knee, hip, and back angles, and SD of ankle, knee, hip, and back angular velocities. Cross correlations of ankle angle and COM position, hip angle and COM position, ankle angle and hip angle were also performed to quantify AP postural strategy in terms of ankle strategy and hip strategy. A two-way repeated measures ANOVA was used to determine significant effects of fatigue. Three main findings emerged from this investigation. First, participants adopted a slight forward lean when fatigued. Second, changes in sway involved increased variability in joint kinematics at different joints. Despite these changes, ankle angle correlated well with AP COM position. Third, global measures of COM and COP did not reveal localized changes in sway. The results of this study indicate that additional or multivariate measures of sway are necessary to understand how fatigue affects movement patterns during quiet standing. This work was supported in part by Jeffress Memorial Trust, Richmond, VA and grant # R01 OH007882 from the Centers for Disease Control and Prevention.

THE DESIGN OF AN AUTOMATED PIEZOACTUATOR-BASED SCOPE SYSTEM. Joshua L. McCroskey, Daniel M. Hambright, Allan Bishop, Karla K. Mossi & Kam K. Leang, Department of Mechanical Engineering, Virginia Commonwealth University, Richmond VA, 23284-3015. We present the design of a piezoelectric-actuator-based system that enables automated and accurate positioning of the optics in a sight device. It is noted that current devices require manual adjustment (by hand) and the accuracy of the system depends on the operator skills. Additionally, the manual adjustment provides limited precision. However, by automating the process and using a piezoelectric actuator to position the optics, quick response and precise target location with respect to target distance can be achieved. In particular, the relatively-high positioning bandwidth of the piezoelectric actuator ensures fast target location. We describe the design of the mechanical system as well as the feedback controller. We show experimental results to demonstrate proof-of-concept.

TRIP RECOVERY: CAN WE IMPROVE IT THROUGH PRACTICE TO PREVENT FALLS?. K.A. Bieryla[1], M.L. Madigan[2,4] & M.A. Nussbaum[3,4], [1]Mechanical Engineering, [2]Engineering Science and Mechanics, [3]Industrial and Systems Engineering, [4]School of Biomedical Engineering and Sciences, [1,2,3]Virginia Tech, Blacksburg VA 24061, [4]Virginia Tech Wake Forest University, Winston-Salem, NC 27157. The purpose of this study was to determine if repeatedly exposing older adults to a simulated trip would result in motor learning. Six older adults (mean age 71.6, SD 5.5) participated in the study. The experiment consisted of two identical testing sessions separated by one week. While in a safety harness, participants stood on a treadmill that was then quickly accelerated to simulate a trip. Subjects were instructed to step over an obstacle with their right foot and recover their balance. Ten simulated trips were performed. Whole body kinematics and lower extremity EMG were collected. A two-way repeated measures ANOVA was conducted on each dependent measure of trip recovery performance with trial and session as independent measures. Several measures showed a main effect of trial, indicating short-term adaptation including maximum trunk angle, time to reach maximum trunk angle, maximum trunk angular velocity, time to reach maximum trunk angular velocity, and onset times of the swing leg tibialis anterior (TA), vastus lateralis, and medial hamstring (MH). Several measures showed a main effect of session indicating motor learning including trunk angle at toe off, and onset times of the swing leg TA, MH, medial gastrocnemius (MG), and stance leg MG and MH. In conclusion, older adults were able to improve their ability to recover from a simulated trip, and these improvements can be attributed, at least in part, to motor learning.

QUANTIFICATION OF TREMOR IN PARKINSON DISEASE. C.R. Dosier, S. Hijaz, P.A. Wetzel, Biomedical Engineering Department, Virginia Commonwealth University, Richmond VA 23298. Parkinson disease (PD) is movement disorder caused by a degradation of dopamine levels in the brain resulting in a variety of symptoms including tremor. A frequent problem during clinical diagnosis and evaluation of PD is that measurements of tremor are often subjective and difficult to quantify. To address this problem we developed a portable device that can accurately provide quantitative, objective measurements of tremor behavior. Our system utilizes MEMs based accelerometers which are used to provide quantifiable measurement of tremor position (amplitude) and tremor frequency.   The accelerometer signals are acquired through a data acquisition module (National Instruments, NI USB-6009) which is interfaced to a notebook computer via a USB port connection.   Control of the data acquisition module, signal processing algorithms, real-time display of the tremor waveforms and storage of waveform data were developed using LabVIEW Version 8 (National Instruments). Future work includes quantification of patient tremor during clinical assessment.

COMPUTATIONAL MODELING OF THE TURTLE UTRICLE. Julian L. Davis & John W. Grant, Dept. of Engr. Sci. & Mech., Va. Polytechnic Inst. & State Univ., Blacksburg VA 24061. The utricle is an organ in the inner ear that senses tilt and linear acceleration of the head. The utricle is composed of a layered structure and operates through shear deformation.   Hair cells are contained in the rigid

neuroepithelial layer whose upper surface is referred to as the macula. The macula serves as the supporting surface for the remaining layers (arranged from most to least compliant): the column filament, compact gel, and otoconial layers. Hair bundles extend from the cuticular surface of hair cells, located at the macula, into the upper layers of the utricle. As the layers of the utricle deform in response to an inertial excitation, bundles deflect which in turn depolarizes hair cells. This depolarization then generates neural action potentials that travel to the central nervous system, and are interpreted as head tilt or head movement. The utricle has been modeled with simple geometries in an effort to understand how its layered structure effects the stimulus of hair bundles. This research investigates the effect of three common simplifying geometries on the stimulus of hair bundles: 1) Curvature of the macular surface, 2) Macular perimeter and 3) Varying layer thickness. By modeling the utricle in its full three dimensional geometry, we can systematically remove each of these variables to investigate their effects on the stimulus of hair bundles. (Supported by: NIH-R01 DC 05063)

NONINVASIVE BLOOD PERFUSION MEASUREMENT ON THE KIDNEY OF AN ANESTHETIZED RAT. Ashvinikumar V. Mudaliar[1,2], Brent E. Ellis[1,2], Patricia L. Ricketts[1,2], Otto I. Lanz[1,3], Elaine P. Scott[1,2] & Thomas E. Diller[1,2], [1]Virginia Tech Wake Forest University School of Biomedical Engineering and Sciences, [2]Department of Mechanical Engineering, [3]Department of Small Animal Clinical Sciences, Virginia Tech, Blacksburg, VA 24061. Blood perfusion represents the local, multi-direction blood flow through capillaries and intracellular spaces of living tissue, and it is crucial in the assessment of many physiological phenomena, such as skin grafts, burn injuries, head traumas, and tumor detection. A noninvasive probe has been developed to determine blood perfusion. It consists of housing and a 1cm 1cm heat flux sensor that is attached directly to the tissue using double-sided tape. To validate the qualitative performance of the blood perfusion probe, the kidney of an anesthetized rat was used as an experimental model to provide controlled perfusion in living tissue. The kidney is highly perfused organ and the blood supply to the kidney can be controlled easily by occluding and opening the renal artery and vein pair. The measured thermal event is created by convective cooling on the top surface of the sensor using an array of impinging jets through the holes in the housing. The jet impingement onto the sensor causes a measurable heat flux response from the tissue. The air is then exhausted through an outlet provided in the housing. The blood perfusion and contact resistance are estimated using a parameter estimation code, which employs a Gauss minimization technique. The code compares the recorded heat flux data to numerical solutions of the Pennes bioheat equation. The rat kidney test clearly demonstrates good repeatability and sensitivity of the probe and that the probe could be used in vivo.

DYNAMIC MECHANICAL ANALYSIS OF INDUCED WEAR ON ARTICULAR SURFACES. K. J. Shields & J. S. Wayne, Orthopaedic Research Laboratory Department of Biomedical Engineering, Virginia Commonwealth University, Richmond, VA 23298. The development of a suitable method for repair and replacement of damaged cartilage has been a challenging area of orthopaedic research. Healthy cartilage experiences relatively low wear despite demanding

loading patterns. Injured or diseased cartilage experiences increased wear and frictional properties. Repaired surfaces may also have increased frictional characteristics that compromise the success of the reparative technique. Typical quantitative techniques for analyzing the effectiveness of a cartilage repair have been characterizing the mechanical response in static compression and/or tension tests. The current study develops a method for analyzing static stress relaxation data from articular surfaces to predict dynamic characteristics (storage and loss modulus and tan δ for a range of frequencies) and apply the method to tests on bovine femoral condyles before and after inducing wear. Wear is induced on the specimens with a polished aluminum plate applying 20% compression to the tissue and allowing a translation of 10mm at 1Hz for 1 hour. After equilibration for 1 hour, the stress relaxation and dynamic cyclical testing is repeated. The dynamic cyclical testing at 1Hz allows for a comparison to the predicted dynamic characteristics at 1Hz from stress relaxation data. Future endeavors include measuring the coefficient of friction (μ) of normal and repaired surfaces in real time while inducing wear. These quantitative measures may help tailor the properties of tissue engineered cartilage to increase the chance of surviving normal articulation without the continuation of fibrillation and extracellular matrix degeneration.

MODELING AND CONTROL OF A SHAPE MEMORY ALLOY ACTUATOR. Guy N. Tchoupo[1], Karla M. Mossi[2], & Kam K. Leang[3]. Department of Mechanical Engineering. Virginia Commonwealth University, Richmond, VA 23284. In this work, we present the control of a shape memory alloy actuator (SMA). SMA is a smart material with the ability to emember its shape even after experiencing significant deformation. For example, at low temperature an SMA can be deformed and its remains in this state until it is heated. This unique property can be exploited to create SMA- based actuators, and compared to other smart material-based actuators (such as piezoelectric ceramics and magnetostrictive devices), SMA actuators offer relatively large strains (up to 8%) and high strength-to-weight ratio. These advantages make SMAs ideal for a wide variety of advanced actuators designs and miniature applications, such as tools for minimum invasive surgery. But unfortunately, SMA actuators exhibit significant hysteresis effect that can lead to loss in positioning precision. In this work, we design a controller to minimize positioning error due to hysteresis. We present experimental results and discuss the performance of the controller, in terms of achievable precision and implementation challenges.

MECHANICS AND STRUCTURE OF VESTIBULAR HAIR BUNDLES. Corrie E. Spoon & John W. Grant, School of Biomedical Engineering and Sciences, Virginia Tech-Wake Forest Univ., Blacksburg VA 24061. The structure of sensory hair bundles in the utricle is highly varied and organized. Characteristic bundle morphologies are observed in the different regions, striola and extrastriola, of the utricle. The functional significance of this variation and its impact on mechantransduction remains unknown. In efforts to further this understanding, we have measured the steady-state stiffness of hair bundles of varying morphology and location in the turtle utricle. All measurements where performed under a light

microscope with a 100X liquid immersion objective (NA = 1.0) with DIC optics. Bundles were deflected in their excitatory directions with a flexible glass fiber positioned at the tip of the kinocilium. Bundle stiffness was determined from measurements of the applied displacement at the base of the whisker, the whisker stiffness, and deflection of the kinocilium tip. To characterize bundle morphology, we measured array length (distance from the tall to short end of the bundle) and heights of the kinocilium, tallest stereocilia and shortest stereocilia. From these values the KS ratio (height of the kinocilium/height of the tallest stereocilia) and slope ((tallest – shortest stereocilia height)/array length) were calculated. The stiffness was found to vary with location on the macula. The bundle stiffness measurements in the striolar and extrastriolar regions were 42 ± 25 (n=28) and 10 ± 0.9 (n=21) $\mu N/m$, respectively. In the striola, stiffness declines systematically from the line of polarity reversal to the medial extrastriola. Bundle stiffness and structure were shown to covary. The stiffest bundles demonstrated a characteristic morphology including short kinocilia, low KS ratios and steep slopes.

A HUMAN COMPUTER INTERFACE THAT OPERATES WITH GAZE AND EYE-BLINKS. Federico A. Puma & Paul A. Wetzel, Dept. of Biomedical Eng., Virginia Commonwealth University, Richmond VA. A method for a real-time communication system is presented. The system uses the user's gaze to control cursor movement over a computer screen. The creation of an innovative algorithm, allows an efficient and accurate determination of gaze position. This algorithm combines eye position data and head position data in real-time to output the direction of the user's line of sight. Eye movements are measured with a pupil-corneal reflection device and head movements are measured with a magnetic tracking system. Another important feature of the interface is the ability to detect and classify the user's eye blinks in order to provide input to the computer in the form of mouse clicks. Voluntary eye-blinks are recognize when the duration of a blink event surpasses a pre-fixed value. Voluntary blinks are then used to trigger mouse clicks and therefore, enable interaction. The system is intended to provide an alternative input modality for human computer interaction systems. Preliminary tests and results prove that the system is capable of individuals whose only channel of interaction is through their eye movements or to individuals that, for any reason are unable to use their hands to control cursor movement.

IN VITRO FLOW VISUALIZATION STUDY OF THE INTERFACE BETWEEN OUTFLOW GRAFT OF VENTRICULAR ASSIST DEVICE AND AORTA. Suhas M. Thatte & Gerald E. Miller, Department of Biomedical Engineering, Richmond VA 23298. For left ventricular failure, heart transplant is the best treatment but due to limited donor hearts and ineligibility of some patients to get a transplant, heart assist devices are considered as an alternative to assist the failing ventricle and even as destination therapy. Numerous in vitro and animal trials are used to study the flow fields in the artificial ventricle to avoid hemolysis and thrombosis, but the effect of the flow fields due to the angle of the LVAD insertion into the aorta are neglected. We have used 30, 60 and 90 degree glass models to signify different angles of the surgical end to side anastomosis. Particle Image Velocimetry is used

to study the flow fields at the interface. 30 degree angle was determined to be the optimum angle amongst the three as it kept stagnation zone, recirculation patterns, flow reversal, high blood shear rate and other flow irregularities to a minimum. This may lead to reduced blood trauma, hemolysis and thrombosis in an in vitro setting.

Botany

BETULA UBER,THE VIRGINIA ROUND-LEAF BIRCH: THE BEGINNING OF THE END, OR THE END OF THE BEGINNING? Kevin G. Jones & Carnita Owens, Department of Natural Sciences, UVA's College at Wise, Wise, VA 24293. As the first woody taxon to be granted inclusion on the Federal List of Endangered Species, *Betula uber* (Ashe) Fernald, the Virginia round-leaf birch, occupies a unique niche in the floral history of south west Virginia. Given the resources devoted to its preservation, it is perhaps surprising that the species-level status of *B. uber* remains controversial, and some regard it merely as a variety of *B. lenta*, a species from which it differs morphologically only in leaf shape. The taxonomic difficulties afforded by *B. uber* are typical of those found across the genus *Betula* as a whole, where extensive hybridization and introgression events have confused definition of taxa within the genus. To address this issue, we have sequenced the ITS regions of rDNA for *B. uber* and six other species of *Betula* present in Virginia. Aligned sequences show no length variation, and differ at between three and twelve nucleotide positions for the species considered. Significantly, sequences obtained from four specimens of *B. uber* and three specimens of *B. lenta* are identical, and do not support species-level recognition for *B. uber*. The impact this data may have on further funding for the preservation of *B. uber* is unclear, but we argue that the taxon still merit attention. Preliminary genetic fingerprinting data discriminate *B. uber* and *B. lenta*, and this genetic diversity, potential economic value, and historical significance all justify continuation of a support program for *B. uber*. In addition, *B. uber* represents a useful model system for subsequent study of the genetic basis for leaf morphology, and the impact of leaf shape on colonization by fungal endophytes.

SOROCARP FORMATION IN *POLYSPHONDYLIUM: ALTRUISM,* OR SOCIAL STRIFE? Carla D. Glass, Brendan G. Hunt & Kevin G. Jones, Department of Natural Sciences, UVA's College at Wise, Wise, VA 24293. Dictyostelid slime molds are a group of protists, with a unique lifestyle. Most of the time, dictyostelids live as single-celled amoebae, that divide asexually. When their bacterial food supply becomes depleted, amoebal cells aggregate to form a multicellular 'slug', in which the component amoebae never fuse but retain their individuality, while co-operating as members of an organized 'society'. Subsequently, the slug differentiates into a sorocarp, in which the anterior 20%of the slug convert into a non-viable stalk, supporting the remaining cells which become viable spores, capable of hatching into new amoebae. The stalk cells have often been seen as being altruistic in behavior, but data from *Dictyostelium discoideum* has shown that when different

clones contribute to sorocarp formation, some clones 'cheat' and contribute less than their fair share of cells to the stalk. We are interested in whether cheating behavior also occurs in the genus *Polysphondylium*. In contrast to *Dictyostelium,* this genus is capable of forming microcysts, which might provide an alternative strategy for coping with starvation, rather than risking being cheated on, in a chimaeric sorocarp. The sorocarp of *Polysphondylium* has whorls of branches, each bearing spores. This also suggests the potential for more complex patterns of social strife than occurs in *Dictyostelium*. Here, we report the isolation of clones of *P. violaceum* from forest soil, and their genetic discrimination using PCR and random primers. These fingerprinted isolates will allow testing for 'cheating' through forced chimaeric sorocarp formation, and the spatial localization of clones within them.

ISOLATION AND CHARACTERIZATION OF ROOT ENDOPHYTES FROM HERBACEOUS PLANTS IN THE APPALACHIAN FOREST. T. L. Neece, C. Fultz & K. G. Jones, Department of Natural Sciences, University of Virginia's College at Wise, Wise VA, 24293. This work is preliminary research for a fellowship study this summer. The research is an investigation into the diversity of root endophytes of various herbaceous plants in the Appalachian region. Endophytes are microbial organisms that colonize healthy plant tissue without apparent damage to the host. Some bacteria produce antibiotics and have been identified as being plant endophytes, suggesting a mutualistic relationship. The species of plants used in this research were *Galax aphylla*, *Lycopodium flabelliforme*, *Chimaphelia maculata*, *Tussilago farfara*. Their roots were surface sterilized, sectioned and plated onto tap water yeast extract (TWYE) agar. Bacterial and fungal isolates were collected from the *G. aphylla* and the *L. flabelliforme* samples while the *C. maculata* and *T. farfara* did not yield any isolates. Even though fungal isolates were obtained, the main focus was given to the bacterial isolates. The bacteria from *G. aphylla* and *L. flabelliforme* were Gram positive rods hypothesized to be of the genus *Bacillus,* which commonly inhabits ground soil. Due to a budget freeze, the final stages of the investigation were not concluded. These steps included DNA extraction and amplification of a 730 bp fragment from the 16S rRNA gene. Then the isolates would have been submitted for sequencing and then differentiated through BLAST searches. Even though these steps were not reached, the project showed that the isolation and sterilization procedure will be successful for the summer fellowship research where funding has already been appropriated.

THE *FLORA OF VIRGINIA* PROJECT: A 2005-2006 UPDATE. Marion B. Lobstein, Dept. of Biology, Northern Virginia C.C., Manassas, VA 22205. Virginia, for its landmass, has the most diversity of vascular plant species of any state in the United States. It had the first flora, the *Flora Virginica* in 1739 yet does not have a modern *flora*. The Virginia Academy of Science for over eighty years has supported efforts to produce a modern *Flora of Virginia*. In 2001 the Foundation of the *Flora of Virginia*, Inc, was formed in 2001 and in May 2002 received 501(c) 3 status. Progress continues to be made on the efforts to develop a *Flora of Virginia* including fund-raising and public outreach efforts. Work on the

content of the Flora of Virginia including the nearly 600 illustrations have been commissioned, completed, and funded by VAS funds. Funds awarded from the Gwalthmey Memorial Trust for 2005 will be used to support continuing work on illustrations. The Academy, including the Fellows, continues to provide essential support including financial for this Project. Other progress includes completion of treatments of the dichotomous keys of 101 of the 205-210 vascular plant families in Virginia and the first step in developing species descriptions for approximately 50% of Virginia's 3800 vascular plant species. The second step of species description development has also begun. The University of Virginia Press has offered a contract to publish the Flora of Virginia in 2011-2012.

PHYLOGENETIC ANALYSIS OF *matK*-PSEUDOGENE FORMATION IN THE SUBTRIBE AERIDINAE (ORCHIDACAE). Eric K. Latourelle and David C. Jarrell, Dept. of Biol. Sci., University of Mary Washington. Fredericksburg VA. 22401. This study was part of an ongoing project examining the sequence of the chloroplast gene *matK* from species in the subtribe Aeridinae. The purpose of this study was two fold: first, to create a more accurate evolutionary model of the subtribe and second, to understand the origin of an apparent *matK* pseudogene. In earlier analyses, a clade appeared in which the sequences contained frameshift deletions, a diagnostic event in pseudogene formation. Analysis with the addition of a significant number of new sequences supports previous conclusions that the pseudogene arose once and also shows that the pseudogene most likely resulted from gene duplication and a subsequent loss of function. This pseudogene also seems selectable by apparent PCR primer bias; PCR product from one set of primers (K118F&K1581R) yield sequence which appears to be the functional form, while product from a different set (trnk3914&K1581R), yields sequence with the frameshifts present which indicate a loss of function. Current results and future prospects for this project will be discussed.

PHYLOGENETIC UTILITY OF *PHALAENOPSIS* (ORCHIDACEAE) USING CHLOROPLAST SEQUENCES – AN UPDATE. Y. Lazdun and D.C. Jarrell, Dept. of Biol. Sci., Univ. of Mary Washington, Fredericksburg VA 22401. *Phalaenopsis* is a genus of Orchidaceae, tribe Vandeae, and is currently divided into five subgenera composed of 63 species. Past classification schemes were based on morphology, largely floral, which can be problematic since such characters may be subject to convergent evolution. This study targets regions of the chloroplast genome to develop a more evolutionarily accurate phylogeny. The *matK* and *rps16* introns were used to construct an initial phylogeny of the genus including representatives from all subgenera. This phylogeny showed that the subgenus Phalaenopsis was not monophyletic, however the large subgenus Polychilos appears monophyletic. The subgenera Aphyllae and Proboscidioides also appear as sister subgenera in this analysis. Improved resolution will require an increase in informative characters and additional species sampling, particularly from underrepresented subgenera. The *rpl16* intron and the *rpoB-trnC* spacer were analyzed using percent variability tests to assess their utility for phylogenetic analysis. PCR products have been generated for both the *matK* and *rps16* introns

have been collected from underrepresented subgenera but have not been sequenced as of yet. Sequencing these additional regions and phylogenetic analysis of a combined chloroplast dataset will help determine species relatedness and improve our understanding of the evolutionary history of this genus. (Supported by: UMW Summer Science Institute and Univ. of Mary Washington Research Grant).

PHYLOGENY OF THE GENUS ARACHIS. Sheena A. Friend, Chelsea M. Black, & Khidir W. Hilu, Department of Biological Sciences, Virginia Tech, Blacksburg, VA 24061. *Arachis* (Fabaceae, legume family) contains approximately 70 species, including the peanut crop (*A. hypogaea* L.). The genus has been divided into nine sections based on morphology, geography and cytogenetics . The largest section, sec. *Arachis,* has been further subdivided based on morphology and cytogenetics into three genome groups. Previous studies were either limited in species/section representation or based on molecular data that could not be analyzed phylogenetically. Thus, the systematics of the genus remains in need of an in-depth study. We are using DNA sequence information from plastid *trn*T-*trn*F and the nuclear ITS to examine species relationship in the genus. The resulting phylogeny will be compared to the morphology-based taxonomic treatment. Information on the evolution of the tetraploid crop will also be investigated. Preliminary data from the sequence information of the nuclear ITS confirms that the B and D genome species are more closely related to each other than to the A genome species of section *Arachis*. Also, sequence data has brought into question the validity of two sections of the genus by placing them in other sections. (Supported by the Virginia Academy of Science, and the Graduate Research Development Project, Virginia Tech)

MOLECULAR STUDY OF PEANUT ALLERGEN ARA H 2 ACROSS WILD PEANUT SPECIES. C. M. Black, S. A. Friend & K. W. Hilu, Dept. of Biol., Virginia Tech, Blacksburg VA 24061. Ara h 1 and Ara h 2 are considered the most important genes that contribute to peanut allergy because of 90% serum recognition in peanut sensitive patients. *Ara h 2* has been found to be the more important of these two allergens because *Ara h 2* has a higher frequency of patient recognition, and a smaller amount is needed to initiate a reaction. In the linear form of *Ara h 2*, ten IgE binding epitopes have been identified through amino acid sequence analysis and immmunoblotting. Two of the ten binding epitopes contain a DPYSPS amino acid motif which is considered to be an immunodominant epitope. *Ara h 2* is found in two isoforms, in the smaller isoform, *Ara h 2.01*, two of the ten epitopes contain the DPYSPS domain. In the larger isoform, *Ara h 2.02*, a twelve amino acid insertion that contains a third DPYSPS epitope was detected. This additional DPYSPS domain rendered *Ara h 2.02* more potent than *Ara h 2.01*. Based on this finding, wild species having an *Ara h 2* sequence fewer or no DPYSPS epitopes could potentially be less allergenic. In this experiment, gene sequencing and ELISA immunological assays will be used to look at wild species closely related to the peanut plant in order to find less harmful genes that could potentially be inserted into the peanut crop in order to reduce the risk of anaphylactic shock in consumers allergic to peanuts.

THE VIRGINIA MASTER GARDENER PROGRAM: MORE THAN YOUR AVERAGE GARDEN VARIETY. David D. Close, Dept. of Horticulture, Virginia Polytechnic Institute and State Univ., Blacksburg VA 24141. The Virginia Cooperative Extension (VCE) Master Gardener program has existed since 1979. Horticulture is used as a platform for training volunteer community educators. Once trained, these volunteers deliver programs and offer training to their fellow citizens through a variety of means and at a variety of venues. These specially trained volunteers contribute to projects focused on sustainable landscape management practices through outreach, teaching, and research. In 2005, more than 4,000 active, certified Maser Gardener volunteers contributed more than 309,500 hours of service and worked with more than 502,000 fellow citizens. The volunteer time was equal to 154 full-time equivalents and had an economic value of $5.58 million. The impacts of this effective program include: promoting and implementing good land stewardship practices, actively engaging youth and the leaders working with youth, emphasizing sustainable landscapes that provide economic returns, providing an avenue for improved nutrition and food security, and contributing to an overall higher quality of life. The VCE Master Gardener volunteers truly epitomize the mission of Cooperative Extension in that they deliver cutting edge information to their family, friends, and neighbors through an educational process that is based on community needs and issues.

ANOMALOUS "PERFORATIONS" IN SECONDARY XYLEM OF THE *ACALYPHA VIRGINICA* COMPLEX (EUPHORBIACEAE). Alexa Jahdi, Carolyn B. Marks, & W. John Hayden, Department of Biology, University of Richmond, Richmond, VA 23173. Previous light microscope-based studies of wood structure of local species of the *Acalypha virginica* complex revealed structures interpreted as anomalous perforation plates. Anomalous "perforations" were re-examined by means of scanning electron microscopy and laser scanning confocal microscopy, techniques that reveal more detail than found in the earlier studies. Whereas ordinary perforations form by hydrolysis of primary cell walls, we show that primary wall material is retained in anomalous "perforations." Anomalous "perforations" are thus comparable to very large simple pits with pit membranes and are not truly perforated. We hypothesize that retention of primary walls in anomalous "perforations" permits random synthesis of secondary wall material in the "perforation" region, resulting in the various partial bars, loops, and serpentine outlines observed. Regular and frequent occurrence of vessel element-like cells with anomalous "perforations" in *Acalypha deamii*, *A. rhomboidea*, and *A. virginica* suggest functional/adaptive significance, perhaps forming water reservoirs interspersed among the ordinary conducting vessels.

THE GENUS *ACALYPHA* (EUPHORBIACEAE) IN YUCATAN, MEXICO. Nina Bhattacharyya & W. John Hayden, Department of Biology, University of Richmond, Richmond, VA 23173. Recent progress in the floristic botany of *Acalypha* in the Yucatan Peninsula is reported. The regional scope of this effort encompasses the Mexican states of Campeche, Quintana Roo, and Yucatan, and

corresponds closely to a natural floristic region defined by low elevation and limestone bedrock. Information compiled for each species is synthesized from the literature, study of herbarium specimens, and study of many species in the field. Useful characters for distinguishing Yucatan species of *Acalypha* include: woody versus herbaceous habit; presence and type of pubescence on aerial organs; leaf size and shape; stipule size and morphology; pistillate inflorescence architecture; morphology and size of pistillate bracts; and the absence or presence and form of allomorphic flowers. Current knowledge supports the recognition of ten native and two cultivated species of *Acalypha* for Yucatan. Several names in frequent use in the region must be reduced to synonymy. One species, *Acalypha gaumeri*, is endemic to the region. Results will contribute towards two ongoing floristic projects, an illustrated guide and a detailed ethnoflora.

QUALITY CONTROL AND ASSURANCE REGARDING A STANDARDIZED METHODOLOGY IN PHYTOPLANKTON AND PRIMARY PRODUCTIVITY MONITORING IN CHESAPEAKE BAY AND VIRGINIA TRIBUTARIES. T.A. Egerton, H.G. Marshall, & K. Nesius. Dept. Biology, Old Dominion Univ., Norfolk, VA. The Chesapeake Bay Phytoplankton Program in Virginia began in 1985 monitoring phytoplankton composition and abundance. Consistency in all procedures with strict QA/QC standards have been maintained throughout the program. Monthly collections of 2 15 l composite carboy samples are taken above and below the pycnocline at each station (14), followed by replicate sub-samples from each set, combined, reduced to a 40 ml concentrate through a settling/siphoning protocol. The samples are fixed in Lugol's solution, preserved with buffered formalin. Cells are identified and counted using modified Utermohl protocol and inverted plankton microscopy. Random fields are examined at 300 and 600x, and the entire settling chamber scanned at 150x. Autotrophic picoplankton analysis was added in 1989, using epifluorescence microscopy, with productivity (C-14) measurements added in 1989, both taken during the phytoplankton collections, along with samples for water quality analysis. Data are submitted to the Chesapeake Bay Monitoring Program and made available online (www.chesapeakebay.net). Supported by Virginia Department of Environmental Quality and USEPA.

ANTIOXIDANT CONTENT OF FRESH AND PROCESSED STRAWBERRIES. Kelley K. Gibbons[1], Michael H. Renfroe[2], Patricia B. Brevard[1] & Robert E. Lee[3], Dept. Health Sci.[1], Dept. Biol.[2], & Dept. Math. & Statistics[3], James Madison University, Harrisonburg, VA 22807. Berries are a rich source of antioxidants which are thought to help prevent some chronic diseases and have multiple health benefits. We determined the antioxidant concentration of fresh, frozen, and freeze-dried strawberries, and strawberry jam, with the aim of identifying which contains the highest antioxidant level. Antioxidants were extracted and the hydrophilic antioxidant activity (HAA) and lipophilic antioxidant activity (LAA) were measured using the $ABTS/H_2O_2/HRP$ decoloration method. Differences in HAA and LAA content were analyzed using a one-way analysis of variance (ANOVA), and

pairwise comparison of means was completed using Dunnett's T3 due to heterogeneous variances. Differences in the TAA were compared using 95% confidence intervals. Mean TAA for freeze-dried strawberries based on "as consumed" weight (CW) was significantly higher than fresh strawberries, frozen strawberries, and strawberry jam. Mean TAA based on dry weight (DW) for fresh strawberries was significantly higher than freeze-dried strawberries, frozen strawberries, and strawberry jam. This study suggests that strawberries, especially freeze-dried and fresh strawberries, are valuable sources of antioxidants.

Chemistry

A PIROUETTE DANCE ON A METALLOFULLERENE SPHERE: SYNTHESIS AND CHARACTERIZATION OF REGIO-INTERCONVERTIBLE N-TRITYLPYRROLIDINO DERIVATIVES OF $Sc_3N@C_{80}$ I_h ISOMER. <u>Ting Cai</u>[1], Liaosa Xu[1], Mark R. Anderson[1], Carla Slebodnick[1], Harry W. Gibson[1], Harry C. Dorn[1], Alan Balch[2] and Marilyn Olmstead[2], [1]Dept. of Chem., Virginia Tech., Blacksburg, VA. 24060 and [2]Dept. of Chem., Univ. of California, Davis, Davis, CA. 95616. Trimetallic Nitride Templated Endohedral Metallofullerenes (TNT EMFs), the most abundantly formed endohedral metallofullerenes, have attracted much attention since their discovery. Functionalization of the TNT EMFs provide unique materials useful for a number of diagnostic (MRI and X-ray contrast agents) and therapeutic medical applications. In this paper, we reported the synthesis and characterization of N-tritylpyrrolidino derivatives of the $Sc_3N@C_{80}$ I_h isomer. The I_h isomer predominantly forms two monoadducts as well as a little of the bisadduct. The two monoadducts are a 6,5 ring junction adduct and a 6,6 ring junction adduct, which are fully characterized by NMR spectroscopy and X-ray crystallography. A kinetic study suggests that the 6,6 ring junction adduct is the kinetically controlled product, it can interconvert into thermodynamic product 6,5 ring junction adduct at elevated temperatures. The difference in the thermal stabilities of two monoadducts will be also discussed as well as the kinetic parameters of the interconversion process, the electrochemical properties, and computational studies. In addition, these products are useful precursors to N-(3-maleimidopropionyl)-3,4-fulleropyrrolidine which can be used as the adapter for coupling proteins for targeted therapies utilizing $Lu_3N@C_{80}$ encapsulated with the radionuclide, Lu-177.

OPTIMAL EXPRESSION OF THE CLONED HUMAN CAP METHYLTRANSFERASE IN *E. COLI*. <u>Jeanhee Chung</u>, Michael Pickup, Kevin D. Kim and Thomas O. Sitz, Dept. of Biochemistry, Virginia Tech, Blacksburg, VA 24061. The 5'-cap structures in eukaryotic mRNAs are methylated in the N-7-postion of the guanine base by the guanine-7-methyltransferease (GMT). This modification is very important in gene expression because if the cap is not methylated the mRNA is not translated into protein. Dr. Shuman at Sloan-Kettering sent us two plasmids, one containing the coding sequence for the full length human GMT and the other coding for the deletion mutation with 120 amino acids deleted

from the N-terminus (120). These plasmids were transformed into the E. coli host cells, BL21(DE3) codon plus. These bacteria were streaked on agar plates and clones containing a high level of enzyme activity were isolated. We were able to use the his-tag system to isolate the human GMT. When the enzyme was applied to a Ni $^{+2}$ column the his-tagged protein bound to the column. The enzyme was eluted with 1 M imidazole. With both the full length and especially with the deletion mutation significant precipitation of the enzymes occurred. When the non-ionic detergent, Triton-X 100 was added to the elution buffer the enzyme activity was almost zero. However when EDTA (a chelating agent) was added to the collection tube high levels of enzyme activity were found. It would appear that high levels of imidazole used to elute the enzyme from the column were also removing Ni which allowed the enzyme to form aggregates. We were able to use lower concentrations of imidazole to elute the enzyme, 0.2 and 0.3M. Large amounts of active GMT were isolated when EDTA was added and low concentrations of imidazole were used to elute the human methyltransferase from the Ni-column.

PREDICTING THE SINGLET OXYGEN QUANTUM YIELD OF HUMIC SUBSTANCES FROM SPECTROSCOPIC PROPERTIES. Renee M. Dalrymple and Charles M. Sharpless, Dept. of Chem., University of Mary Washington, Fredericksburg VA 22401. Upon absorbing solar radiation humic substances (HS) produce $^1O_2$ which degrades organic pollutants such as phenols. It is hypothesized that the quantum yield of $^1O_2$ (Φ_{so}) for a humic substance can be predicted from the ratio of the absorbance at 250nm to the absorbance at 365nm (E2/E3 ratio) since spectroscopic properties of HSs should be related to their photochemical properties. The quantum yield was determined by monitoring the rate of reaction of HS with furfuryl alcohol (FFA), which reacts specifically with $^1O_2$. Phosphate buffered solutions of Suwannee River NOM, pH 4, 7, and 10, Nordic NOM, pH 4 and 7, and Nordic humic and fulvic acid (HA and FA), which are the photoreactive subfractions of NOM, were prepared. The solutions were placed in a petri dish and exposed to ultraviolet light while stirring. Samples were taken periodically and analyzed for FFA content using High Pressure Liquid Chromatography (HPLC). Absorbance spectra were collected and the E2/E3 ratios were calculated for the HS solutions at each pH. The Φ_{so} values were plotted versus E2/E3 and appear to have a linear trend. These results indicate that it may be possible to predict the quantum yield of $^1O_2$ from natural samples by simple absorbance measurements.

THERMAL DECOMPOSITION OF $M(NH_3)_2C_2O_4$(M= Cu, Zn). Maura Goodrich and T.C. DeVore, Dept. of Chem., James Madison Univ. MSC 4501, Harrisonburg, VA 22807. Copper ammine oxalate and zinc ammine oxalate dihydrate were prepared by placing the corresponding metal oxalate in contact with the vapor over a saturated ammonia solution for 24 hours. The IR spectrum indicated that ammonia had been added to each compound and the observed mass change indicated that it was the diammine complex. The thermal decomposition of both compounds was investigated using thermal gravimetric analysis (TGA) and differential scanning calorimetry (DSC). The copper complex decomposed in two

steps. The ammonia was lost between 200 and 250 $^{\circ}$C to form copper oxalate which decomposed at ~ 300 $^{\circ}$C. The decomposition of the zinc complex was more complicated in that 5 decomposition steps were observed. The observed mass losses are consistent with the intermediates being $Zn(NH_3)_{1.75}C_2O_4$, $Zn(NH_3)C_2O_4$, $Zn(NH_3)_{0.33}C_2O_4$, and ZnC_2O_4. The enthalpies of each compound have been estimated using the DSC data and the balanced chemical equations for each decomposition step.

PREPARATION AND CHARACTERIZATION OF HYDROGENATED TRIMETALLIC NITRIDE ENDOHEDRDAL METALLOFULLERENES. Wujun Fu, Harry W. Gibson, and Harry C. Dorn, Dept. of Chem., Virginia Tech, Blacksburg, Va 24060. Since the discovery and isolation of trimetallic nitride templated endohedral metallofullerenes (TNT EMFs),[1] the chemical modification of this new material has attracted widespread interests. Due to the unique molecular structure of fullerenes and endohedral metallofullerenes, the carbon cage is considered to be the only allotropic form of carbon that can be hydrogenated and dehydrogenated reversibly.[2] Thus, the hydrogenation of fullerenes and metallofullerenes is of interest for hydrogen storage and new battery applications. In this paper, we will report the hydrogenation of the carbon cage surface of TNT EMFs, such as, $Sc_3N@C_{80}$ by the Benkenser reduction reaction. A highly reduced TNT EMF was synthesized and characterized by HPLC, MALDI-TOF MS, ^{1}H NMR and UV-vis spectroscopies.

EVIDENCE AGAINST A 'DOUBLE INVERSION' MECHANISM IN MEMORY OF CHIRALITY ALKYLATIONS OF 1,4-benzodiazepin-2-ones. Danny C. Hsu, Polo C. H. Lam, Joe C. DeGuzman, and Paul R. Carlier, Dept. of Chem., Virginia Tech, Blacksburg, VA 24061. We have previously reported the enantioselective synthesis of "quaternary" 1,4-benzodiazepin-2-ones **3** via memory of chirality. The high enantiomeric excess realized in the retentive synthesis of **3** has been attributed to the formation of enantiopure, *conformationally* chiral enolate (*M*)-**2**, and subsequent concave-face, contra-steric alkylation.
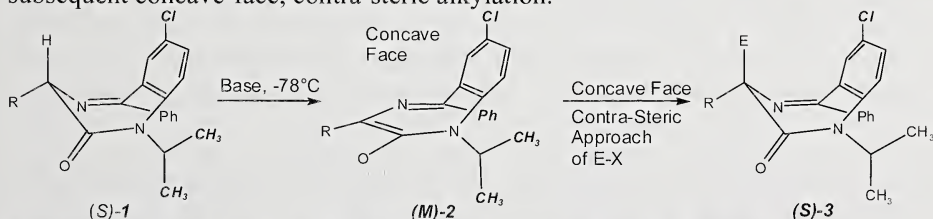
However, another possibility is that deprotonation of (*S*)-**1** affords the enantiomeric enolate (*P*)-**2**; subsequent convex-face, sterically controlled alkylation would then yield (*S*)-**3**. In this paper we report NMR studies that establish concave-face alkylation. Thus, the 'double inversion' mechanism can be ruled out.

ANALYTICAL STRATIGIES RELATED TO ACCURACY AND PRECISION IN AN ICP-MS TRACE ANALYSIS PROBLEM IN INSTRUMENTAL ANALYSIS. Dana M.Edwards, <u>Ashley M. Lakner</u>, Daniel M. Downey, and James J. Leary, Dept. of Chem., MSC 4501, James Madison Univ., Harrisonburg, VA 22807. Students in Instrumental Analysis at JMU routinely analyze commercial (OTC) multivitamin/multimineral supplements for the trace elements chromium, molybdenum, and selenium using an inductively coupled plasma mass spectrometer (ICP-MS). Questions have persisted concerning both the accuracy and the precision of determinations. This work summarizes some of the analytical strategies that have been used to minimize both random and systematic errors associated with this experiment. The merits associated with using one or more internal standards will be presented. Results will be presented for determinations of samples that have been "spiked" with known amounts of the analytes. Finally, a comparison will be made between the results obtained when a calibration curve is used and the results that are obtained when the experiment is performed utilizing the standard addition approach. Proprietary considerations have made it impossible to know the scatter associated with the formulation and the manufacturing of any component in OTC supplements. However, it is possible to document the random error contributions from other sources (e.g. lab technique, calibration curve, instrument fluctuations); having these values, it becomes possible to estimate the total standard deviation associated with the analytical protocol.

SYNTHESIS AND CHARACTERIZATION OF PEROXYNITRITE PREPARATIONS FOR PHOTOCHEMICAL STUDIES. <u>Jennifer M. McKay</u> and Charles M. Sharpless, Dept. of Chem., University of Mary Washington, Fredericksburg, VA 22401. The photolysis of nitrate is known to produce, among other things, hydroxyl radicals ($\cdot$OH), a highly reactive species that can destroy hazardous organic pollutants in natural waters by initiating a series of oxidative degradation reactions. The exact mechanism by which this $\cdot$OH formation occurs is still under debate. Some of the answer may lie in the study of peroxynitrite (ONO_2^-), a reactive intermediate in nitrate photolysis and key precursor of peroxynitrous acid, which decomposes to produce $\cdot$OH. Additionally, few studies of peroxynitrite photochemistry have been conducted and more needs to be done to better understand this aspect of the overall nitrate photolysis mechanism. Peroxynitrite suitable for photochemical studies was synthesized, therefore, by reacting nitric oxide with alkaline hydrogen peroxide (H_2O_2) in the presence of O_2. The amount of peroxynitrite generated was determined from the absorbance of the solution at 302 nm. To account for any interferents, a solution of the background matrix was created by acidifying the final solution. Peroxynitrite's true absorbance equaled the difference between the two mixtures' absorbencies. The calculated peroxynitrite concentration was 4.58 mM. The acidified solution, readjusted to pH$\approx$7, was used to analyze for nitrite and nitrate. The nitrite concentration was determined to be 218 μM using a colorimetric analysis via the method of standard additions. Nitrate was determined to be 193 μM using the cadmium reduction method. Peroxide was determined to be 19.5 μM. The nitrite and nitrate observed were probably due to peroxynitrite decomposition.

STABILITY AND ACTIVATION OF THE CLONED HUMAN CAP METHYLTRANSFERASE. Amanda J. Misiewicz and Thomas O. Sitz, Dept. of Biochemistry, Virginia Tech, Blacksburg, VA 24061. The 5'-ends of eukaryotic mRNAs are highly modified with a structure that is called a "cap". It caps the end of the molecule and prevents it from attack by 5'-exonucleases. The most important function of this "cap" is to allow the binding of ribosomes to allow the mRNA to be translated into protein. The most important of the modifications of the cap structure is the methlylation of the guanine base in the N-7 position. If the cap is not methylated in this position it is not functional. The human cDNA coding for the guanine-7-methyltransferase (GMT) was cloned in a pET expression system that allowed the expression of the his-tag GMT with 10 histidines at the N-terminus. When enzyme preparations were assayed with low activity the enzyme became more active with time when assayed over 30 minutes. When enzyme with high activity was assayed the kinetics were linear. However when preparations of enzyme with high activity were diluted 30 fold and assayed for 3 hours a dramatic increase of activity was seen in the last 15 or 30 minutes of the incubation. This increase in activity was not affected by incubating the enzyme with either substrate alone (SAM or RNA) for 90 min and then adding the missing substrate. Even when the enzyme was left out of the incubation the same acceleration of apparent activity was seen! Therefore the increase in activity at long time intervals was not a biochemical event. Addition experiments demonstrated that an artifact of the assay system was responsible---specifically the washing of the DEAE-filter paper. However, the increase in activity see at early time intervals up to 30 minutes is a real biochemical phenomenon.

THE SYNTHESIS OF SUBSTITUTED MOLYBDENUM CARBONYL COMPLEXES AS POTENTIAL CATALYSTS. Carolyn Segerdell, Taryn Cummens, D.S. Amenta, and J.L. Gilje, Dept. of Chem., MSC 4501, James Madison University, Harrisonburg VA 22807. We are interested in molybdenum complexes that may be used as catalysts in epoxidation reactions. In this study we have sought to prepare complexes with the general form $CpMo(CO)_3(CH_2)_n$—R, where n ranges from 4-6 and where R is the tosyl group (OTs) or $CpMo(CO)_3$. The anion $CpMo(CO)_3^-$ was allowed to react in a 2:1 ratio with $T_sO(CH_2)_nOT_s$, n = 4-6. The ditosylates as well as the molybdenum complexes resulting from these reactions were characterized using ^1H and ^{13}C NMR spectroscopy as well as infrared spectroscopy.

TARGETING SERINE HYDROXYMETHYLTRANSFERASE FROM THE HUMAN PARASITE *TRYPANOSOMA CRUZI*. Kamran Shahzad, Shivan Desai, Brittany Gettleman and Daniel G. S. Capelluto, Dept of Chem., Virginia Tech, Blacksburg, VA 24061. The human parasite *Trypanosoma cruzi* is the causal agent of the Chagas' disease. Possible therapeutic targets are proteins involved in the metabolism of amino acids and vitamins. Folates are precursor of vitamins that function as a family of cofactors by carrying one-carbon units that are required for the synthesis of thymidylate, purines, methionine and methylation reactions in mammalian cells. The parasite *T.cruzi* is folate auxotroph and thus it depends of the

availability of these molecules in the host and a proper system to transport folates from the environment. Serine is the major source of one-carbon units that are generated by the enzyme serine hydroxymethyltransferase (SHMT). This enzyme catalyzes the interconversion of serine and tetrahydrofolate (THF) to glycine and methylene 5,10 THF. The active site of the enzyme is located at the interface of two monomers in an obligated dimer of dimers. In mammals, SHMT is a tetrameric protein present in both the mitochondria and cytoplasm compartments. Our previous studies indicate that the single *T.cruzi* SHMT presents structural differences compared with the mammalian counterpart. However, the native *T.cruzi* SHMT is unstable and thus making difficult its characterization as a target for drug design. We have cloned and expressed the recombinant *T. cruzi* SHMT in *E. coli*. Initial purification yielded a highly stable and soluble protein. Folate analogs will be tested as specific *T.cruzi* SHMT inhibitors using circular dichroism, isothermal calorimetry, X-ray crystallography and NMR spectroscopy.

METHYLATION OF A LARGE ALKALINE STABLE RNA FRAGMENT IN *E. COLI* tRNA. Nicole M. Tellmann and Thomas O. Sitz, Dept. of Biochemistry, Virginia Tech, Blacksburg, VA 24061. The "cap" structure in eukaryotic mRNA is important for gene expression and is highly modified. The most important of these modifications is the N-7-methylation of the guanine base. Without the methylation of the guanine base in the cap the mRNA will not be translated as ribosomes will not bind to the mRNA. Previously we developed a rapid assay for the determination of the amount of non-methylated cap structure in RNA isolated from various tissues. When I used total *E. coli* RNA as a negative control the level of methyl-accepting activity was very low as expected. However, when E. coli tRNA was assayed the level of methyl-accepting activity was elevated. When the tRNA was isolated from a methyl-accepting assay, hydrolyzed with base, and then analyzed on a DEAE-Sephadex column a large alkaline stable fragment (-5 charge) was found. This is the same size as the "cap" structure found in methyl-deficient RNA isolated from ethionine treated mouse liver. Transfer RNA from two commercial samples (type XX and type XXI) and a methyl deficient tRNA sample that I prepared were analyzed on DEAE-Sephadex columns and the -5 charge fragment was not observed. The inability to reproduce the methylation of a large alkaline fragment may have been due to an artifact in the first experiment or due to the aging of the enzyme sample on storage at -20°. The first assays were performed when the enzyme preparation was about three months old and the last set of data was generated when the enzyme had been stored for eight months. In future experiments, I will isolate the methyltransferase and use it to analyze the tRNA without storage of the enzyme.

THE PREPARATION AND STRUCTURE OF $CeSc_2N@C_{80}$: An ICOSAHEDRAL CARBON CAGE ENCLOSING AN ACENTRIC $CeSc_2N$ UNIT WITH A BURIED f ELECTRON SPIN. Xuelei Wang[1], Tianming Zuo[1], Thomas E. Glass[1], Frank Cromer[1], Harry C. Dorn[1], Marilyn M. Olmstead[2], Alan L. Balch[2], and James C. Duchamp[3], [1]Dept. of Chem., Virginia Tech, Blacksburg, VA, 24061, [2]Dept. of Chem., University of California at Davis, Davis, CA, 95616, [3]Dept. of Chem.,

Emory and Henry College, Emory, VA, 24037. In this paper we report the preparation, purification, and characterization of a mixed trimetallic nitride endohedral metallofullerene, $CeSc_2N@C_{80}$. We will show the single-crystal X-ray diffraction structure which consists of a four atom trigonal planar cluster ($CeSc_2N$) offset with a N atom offset by 0.36 Å inside a C_{80} (I_h) carbon cage. Surprisingly, at ambient temperatures, the ^{13}C NMR spectrum exhibits isotropic motional averaging yielding only two signals (3 to 1 intensity ratio) for the icosahedral C_{80} cage carbons. At the same temperature, the ^{45}Sc NMR exhibits a relatively narrow symmetric signal (2700 Hz) with a small temperature dependent Curie shift. A rotation energy barrier (Ea = 79 meV) was derived from the ^{45}Sc NMR line-width analysis. Finally, the XPS spectrum for $CeSc_2N@C_{80}$ confirms a +3 oxidation state for cerium, $Ce^{3+}(4f^1 5d^0)$, this oxidation state, and the Curie shift, are consistent for a weak paramagnetic system with a single buried f electron spin.

AN EXPERIMENTAL AND THEORETICAL STUDY OF $Sc_3N@C_{68}$: ELECTROCHEMICAL AND RAMAN VIBRATIONAL MODE ANALYSIS. Liaosa Xu[1], Ting Cai[1], Mark R. Anderson[1], Harry C. Dorn[1], Ling-Ling Wu[2], Nathan Swami[2], and Keith Williams[3], [1]Dept. of Chem., Virginia Tech, Blacksburg, VA 24061, [2]Dept. of Electrical Engineering, and [3]Dept. of Physics, University of Virginia, Charlottesville, VA 22908. $Sc_3N@C_{68}$ was produced by encapsulation of Sc_3N in a C_{68} cage that disobeys the isolated-pentagon rule, namely, with D_3 symmetry. The calculations are based on quantum chemical [density functional theory] methods. We first report electrochemistry study of $Sc_3N@C_{68}$ as a technique to characterize the electrochemical properties of this endohedral metallofullerene which was compared to the calculated HOMO-LUMO gap. Also, the vibrational modes of $Sc_3N@C_{68}$ are currently of considerable interest. The calculated metal cluster–cage vibrational modes in far-infrared and Raman spectroscopic studies provide direct evidence for the bonding interaction between Sc_3N cluster and the carbon cage. Translational and rotational Sc_3N modes were found by both theory and experiment which induce the formation of the Sc_3N-C_{68} bonding.

DEVELOPING NEW ANTI-CANCER DRUGS. Shengliang Zhao, Matthew T. Mongelli, Brenda S. Winkel, and Karen J. Brewer, Dept. of Chem., Virginia Tech, Blacksburg, VA 24061-0212. The design and development of antitumor platinum-based complexes has become one of the most important areas of medicinal chemistry. These chemotherapeutic agents used in cancer therapy target DNA. Interactions are based on the four possible interaction modes: external binding, grove binding, intercalating and covalent binding. Platinum complexes are known to covalently bind to DNA, including the antitumor drug cis-diamminedichloraplatinium (cisplatin). The applicability of cisplatin is limited by toxicity, side effects, solubility and tumor resistance. Therefore, new platinum-based complexes have been designed and fabricated to improve the efficiency of the antitumor activity. This presentation will focus on the use of electrochemical and spectroscopic methods to probe platinum complex-DNA interactions. This work is supported by the NSF (CHE-0408445).

A NOVEL FAMILY OF TERBIUM-BASED TRIMETALLIC NITRIDE TEMPLATE ENDOHEDRAL METALLOFULLERENES: $Tb_3N@C_{2n}$ ($40 \leq n \leq 44$). <u>Tianming Zuo</u>[1], Liaosa Xu[1], Kim Harich[1], Harry C. Dorn[1], Marilyn Olmstead[2], Alan Balch[2], and James Duchamp[3], [1]Dept. of Chem., Virginia Tech, Blacksburg, VA 24061, [2]Dept. of Chem., University of California, Davis, Davis, California 95616, [3]Dept. of Chem., Emory and Henry College, Emory, VA 24327. Trimetallic nitride template endohedral metallofullerenes (TNT-EMFs) have many special physico-chemical properties. In this presentation, we report the synthesis, isolation, and characterization of $Tb_3N@C_{2n}$ ($40 \leq n \leq 44$).[3,4] We have recently developed a chemical separation method that was successfully employed in the current study that is based on the chemical kinetic stability of TNT-EMFs relative to empty cage fullerenes and classic EMFs, $M_x@C_{2n}$ ($x = 1{\sim}3$, $n = 30{\sim}50$).[5] These new carbonaceous nanomaterials were characterized by MS, UV-VIS, and X-ray crystallography as well as DFT computational approaches.

Computer Science

THE REQUIREMENT ELICITATION OF SOFTWARE ENGINEERING. Jeff Zadeh, Department of Mathematics and Computer Science, Virginia State University, Petersburg, VA 23806. This paper describes the requirement elicitation of software development. Software is an increasingly important aspect of our daily life in government, banking and finance, education, transportation, entertainment, medicine, agriculture, and law. Unfortunately, there are severe problems in the cost, timeliness, and quality of many software products. The more serious problem is the effect that quality of software can have on the safety-critical issues that directly affect the health of humans. Today software engineering is widely accepted by industry, government, and academia. Software engineering is a rather young and somewhat immature discipline. Software requirements elicitation is the process where the customers' needs in a software project are identified. his process is one of the most important parts of building a software system because during this stage it is decided precisely what will be built. However, requirement gathering needs close interaction between developers and end-users of the system. Obtaining complete requirement information about large software systems is a key challenge in dealing with increasing complexity of a software product. Requirement information can be analyzed to provide a clearer picture about the problems concerning an individual feature or a set of features and over time exhibits a high potential to illustrate software product

Education

STRATEGIES TO ENHANCE LEARNING IN PHARMACY TECHNICIANS. Mary Arnold[1], Tricia Easterling[1] & J. Orion Rogers[2], [1]School of Teacher Education and Leadership and [2]Dept. of Biol., Radford Univ., Radford VA 24142. The objectives of this project were to investigate a variety of instructional methods to facilitate learning, student attitude and performance of ten students enrolled in HLT 250 Pharmacy Technician Internship and Virginia Certification Review that was taught by Mary Arnold at Wytheville Community College during the spring 2006 semester. Authors obtained NIH certification to conduct research with human subjects, the Radford University IRB Committee on Human Subjects Research approved this research, and informed consent was obtained from students. Students were administered a pretest, posttest and attitudinal survey. Class demographics included: five students are 18-22 years old and five students are 23-53 years old, five students have children and five do not, and five students plan to pursue higher degrees while five plan for careers as pharmacy technicians. Methods of instruction included traditional lectures as well as interactive CD-ROMs to engage students in the learning process, to improve midterm and final exam scores in the course, and to improve scores on the Pharmacy Technician Certification Test for the Commonwealth of Virginia. Blackboard 6 instruction was used to provide a study guide on each chapter and six quizzes as well as a discussion board for questions and concerns. Results reveal that the posttest class average of 95% significantly increased ($P < 0.0001$) when compared to the pretest average of 77%. Five students have already taken and passed the Virginia Certification Test, and three are scheduled to take the certification test. Four students earned final course grades of "A", five students earned grades of "B" and only one student earned a grade of "C".

USING THE SCIENCE MUSEUM AS A TEACHING RESOURCE David B. Hagan and Patricia D. Fishback,, Center for Science Education, Science Museum of Virginia, 2500 W. Broad Street, Richmond, VA 23220. The teaching of science at middle and high school levels requires use of laboratory and research equipment not often available to teachers in school buildings. The Science Museum of Virginia presents examples of exhibits and research programs specifically designed to support the teaching of science at this level. The Discover Virginia is an exhibit laid out in four quadrants based on the Virginia Science Standards of Learning for the Earth Science course, generally taught in the ninth grade. Theme areas are: Rocks, Minerals and Natural Resources of Virginia, Virginia on a Moving Continent (Tectonic Plates), Sea Level Changes in Virginia, and Watersheds and Rivers of Virginia. The room has 500 square feet of acoustic paneling covered with high-resolution color printing on cloth medium. Nineteen specimen cases line the room, illustrating examples of minerals, rocks and fossils. The room is designed as a teaching space for the geology and natural history of Virginia. The second program presented is the adaptation of large, expensive physical science exhibits for student research. These include a large diffusion cloud chamber for high energy particle tracks, a 4-meter Earth-moon gravity well, a 1.5 second microgravity drop tower, and a 60 gallon instrumented crystal growing chamber. High school physics

and chemistry students are invited to use these exhibits for Virginia Junior Academy of Science research projects.

DEVELOPING A NEW LABORATORY PROGRAM FOR COLLEGE-LEVEL INTRODUCTORY BIOLOGY.   Ronald S. Mollick, Dept. of Biol., Chemistry, & Environmental Science, Christopher Newport Univ., Newport News VA 23606. CNU instituted new general education requirements at the same time the Department removed General Biology from the major requirements. This meant that the General Biology lab course needed to be restructured for non-majors only. The lab course was reduced to two hour sessions, and lab topics were chosen not to try to cover the scope of Biology, but to teach non-majors what science is and how science is done using biological topics. Each lab topic is now taught typically in two or three sessions per topic. In the first session, students are taught about a subject area and gain experience in how it can be studied in lab. At the end of the first session, they must construct testable hypotheses of their choosing, and design an experimental protocol. During the second session, they will test their hypotheses and gather data. The third session is when they orally present their work and hand in a lab report. This system therefore includes all basic elements of science: observation, creating and testing hypotheses, collecting and working with data, and reporting their findings both orally and in a written form. Most of the lab topics require hands on work, but two of them, Evolution and Ecology, are soft ware based. This partial inquiry based system provides the students with the opportunity to develop their interests and control their work which the literature tells us will lead to greater student satisfaction and better learning.

ENHANCING HIGH SCHOOL BIOLOGY REMEDIATION THROUGH SMART BOARD TECHNOLOGY. Brandi Norman[1], Tricia Easterling[1] & J. Orion Rogers[2], [1]School of Teacher Education and Leadership and [2]Dept. of Biol., Radford Univ., Radford VA 24142. Review of literature reveals that research regarding the use of SMART Board technology in education, particularly with biology remediation students, is relatively limited because it is a fairly new and expensive teaching tool. The literature suggests that the SMART Board interactive whiteboard can be a powerful tool to motivate and engage students in learning and to aid their retention by incorporating a wide range of information from various resources and by accommodating various learning styles. This research included seven students, three males and four females, at Abingdon High School ranging from 15 to 18 years of age. These students were in a biology remediation study hall because they had previously completed high school biology but had not passed the Virginia Biology Standards of Learning (SOL) test. Students were given the released 2004 Biology SOL test as a pretest before beginning remediation using the SMART Board and again as a posttest following eight weeks of remediation. Results reveal that the mean posttest scores were significantly higher after using the SMART Board for biology remediation. A learning preferences survey was also administered to each of these seven students before and after remediation to measure student attitudes about biology and use of technology. The mean of student attitudes and learning preferences did not differ significantly over the course of remediation, so no

correlation was seen between student attitudes/learning preferences and Biology SOL test achievement. Posttest score results indicate that the SMART Board is a valuable tool for remediation of struggling learners in biology.

DESIGN OF A HIGH QUALITY PROFESSIONAL DEVELOPMENT INSTITUTE FOR MIDDLE SCHOOL SCIENCE. J. Orion Rogers, Dept. of Biol., Radford Univ., Radford VA 24142. The No Child Left Behind (NCLB) Act of 2001 requires that experienced middle school teachers who are licensed in middle education or special education meet the definition of "highly qualified". One mechanism to fulfill this requirement is to meet the High Objective Uniform State Standard of Evaluation (HOUSSE) definition by completing an institute in the content area that meets high quality professional development (HQPD) criteria established by the Virginia Department of Education. The objective of this project was to design and implement a HQPD Institute for special education teachers of middle school science. Methods included conducting 30 clock-hours of classroom-focused instruction over three weekends at the Higher Education Center in Roanoke during the spring of 2006. Each weekend institute focused on the Virginia Science Standards of Learning (SOL) for either sixth, seventh or eighth grades, and one morning session discussed the Kansas State University Strategic Instructional Model (SIM). The institutes were designed to enhance teachers' knowledge of scientific investigation through hands-on activities in addition to their content knowledge of physical, life, Earth and space systems science. A pretest designed to simulate the Virginia Science SOL test for eighth grade was given before the first session, and a posttest was administered after the third HQPD session. A formal assessment instrument was used after each of the three sessions to evaluate effectiveness, and modifications were enacted to stimulate engagement. Results revealed that teachers' knowledge was enhanced as evidenced by a pretest class average of 71% and a significantly higher ($P < 0.0088$) posttest class average of 81%.

PRELIMINARY RESULTS FROM A MULTICENTER INVESTIGATION OF THE EFFECT OF NETWORK LATENCY ON PEDAGOGIC EFFICACY. J. C. Squire[1], V. K. Walsh[2], & H. F. Bush[3], [1]Dept. of Electrical and Computer Engineering, [2]Dept. of Mathematics and Computer Science, and [3]Dept. of Economics and Business, Virginia Military Institute. Interactive web-based learning tools are becoming increasingly common to intuitively convey cause-and-effect relationships. There is little systematic investigation of the relationship between network delay and student learning. Our hypothesis is that student understanding is relatively insensitive to small network delays, but exhibits a sharp downwards knee for delays in excess of a few hundred millseconds. If this is true, the time delay associated with that knee has implications for pedagogic software design, client-server computational distribution for web-based apps, and even university IT infrastructure. An interactive software application was designed purportedly to teach Fourier Analysis concepts, but actually embedding a variable delay between the time a student moves a control and the time the screen updates. Students were randomly assigned versions with different delays. Knee location was computed

using a nonlinear least squares fit to find the best-fit of a two-part piecewise linear function. Data using a subpopulation of 42 students from VMI using 8 equally-spaced delays from 0 to 420 milliseconds suggests a knee may exist (225 ± 112 ms), however the small population size results in a high standard error of the mean. As more data is collected, the SEM of the knee location will be reduced, enabling tests such as whether knee location is invariant with respect to age, gender, or major.

REFORM OF INTRODUCTORY SCIENCE COURSES FOR NON-SCIENCE MAJORS: AN ASSOCIATED COLLEGES OF THE SOUTH INITIATIVE. David W. Sukow, Department of Physics and Engineering, Washington and Lee University, Lexington VA 24450. A major issue confronting science education in this county is the scientific literacy, or illiteracy, of non-scientists. As science and technology continue to grow in importance in all aspects of our society, including economic and political arenas, it is crucial that science educators address this issue. The Associated Colleges of the South (ACS), a consortium of sixteen private liberal arts colleges and universities, has undertaken an initiative to improve science courses for students majoring in disciplines outside the sciences. Goals of this program are to increase the visibility of science education issues, provide faculty with expertise and resources to improve science literacy among non-science majors, improve scientific and technological understanding among these students, and to demonstrate the value of confronting this problem through collaborative efforts across institutions. This is accomplished through a program of workshops on course design and assessment, mentoring young science faculty, developing new courses and activities suitable for the target audience, assessing the results of the projects, and sharing widely the best and most effective models thus developed. This initiative is supported by the W. M. Keck Foundation.

UNDERGRADUATE RESEARCH TEAMS: A STRATEGY FOR INCLUSION. Lisa S. Webb, Dept. of Biology, Chemistry, & Environmental Science, Christopher Newport Univ., Newport News VA 23606. Undergraduate research teams are composed of groups of students of varying skill, ability and experience levels working collaboratively on an extracurricular research project. Each team member has a specific role in the project, and each team has a leader who coordinates task assignments and monitors results. The faculty mentor organizes and oversees the project and meets individually and collectively with team members and leaders. Because undergraduate research teams can accommodate students of all skill, ability and experience levels, they can be utilized to include students who have not traditionally been involved in scientific research projects. These include students with low grade point averages, underachieving and/or unmotivated students, students lacking self-confidence, students from underrepresented populations, and non-traditional students; the very students who stand to benefit most from a research experience. Therefore, undergraduate research teams can serve as an effective vehicle for inclusion.

Environmental Science

EVALUATION OF FALL SOIL SAMPLING FOR PREDICTING SPRING INFESTATION OF SECONDARY SOIL PESTS IN CORN. T. Jordan[1], R. Youngman[1], C. Laub[1], T. Kuhar[2], & S. Tiwari[1], [1]Virginia Tech University, Blacksburg, VA & [2]Virginia Tech University, Eastern Shore AREC, Painter, VA. A field study was started in fall 2005 to predict spring infestation levels of secondary soil pests, specifically white grubs (Coleoptera: Scarabaeidae) and wireworms (Coleoptera: Elateridae) in cornfields. Fifteen post-harvest soybean fields were sampled in late October and early November in several eastern Virginia counties using a randomized complete block design with 15 replicates. Current sampling procedures for secondary soil pests are done in the spring prior to planting by visually inspecting a 30-cm^2 by 15-cm deep (standard method) volume of soil for annual white grubs or by using some form of baiting method for wireworms and annual white grubs. This study compared a 20.3-cm^2 by 15-cm deep soil sample with the standard method. Initial results of fall 2005 sampling indicate abundant white grub densities ranging from 0.9-10.1 grubs per standard method. Of the 15 sampled fields, 12 exceeded the economic threshold of 2 grubs per standard method. The 20.3-cm^2 by 15-cm deep sample method was evaluated for its potential to correlate to the standard method after a 2.25 weighting factor (the standard method samples 2.25 x more volume of soil than the 20.3-cm^2 by 15-cm deep method). No significant differences were detected between the two methods after correcting for differences in sampling volume. Wireworms also were found, but numbers were generally low across all fields, averaging less than 1 wireworm per standard method. Sampling is planned for spring 2006, and again in fall 2006 and spring 2007, to evaluate how well fall sampling densities correlate with spring densities.

COMPARATIVE ANALYSIS OF THE IMPACT OF DEVELOPMENT ON THE HEALTH OF TWO STREAM TRIBUTARIES OF THE RAPPAHANNONCK RIVER. Justin Park and Michael Bass. Environmental Science & Geology, University of Mary Washington, Fredericksburg, VA. Monitoring of the ecological impact of the Celebrate Virginia project in Stafford Co. VA has progressed from 2001 thru 2005 by measuring water chemistry parameters and the health of the macrobenthic community. In 2005 water chemistry data showed variations but not many levels above the established EPA/ VDEQ regulations for any parameter. The most prevalent change was in the amount of sediment accumulation seen in the streams. The impact of this embeddeness was seen in changes to the macrobenthic community. Three evaluators of stream health in our study were: the collection of insects used to determine the Hilsenhoff Biotic Index(HBI), the calculation of the Ephemeroptera/Plecoptera/Trichoptera richness(%EPT) and comparing trophic relationship proportions. The HBI indicated a decrease in stream quality at all stations except one, however the HBI's are within the good to very good range. Percent EPT decreased at all stations and the trophic level distribution became increasingly unequal from the previous year. Both the total organism and the total insect population collected showed a decrease.

POND MACROINVERTEBRATE COMMUNITY COMPOSITION ALONG ENVIRONMENTAL GRADIENTS. <u>Sara A. Shakeshaft</u> & Jeremy M. Wojdak, Department of Biology, Radford University, Radford, VA 24142. The number and composition of species that inhabit freshwater ecosystems can reflect current and historical land use in the watershed, physical and chemical characteristics, and biotic interactions. As a preliminary step to understand the invertebrate communities in ponds in southwest Virginia, we conducted a field survey of 14 ponds. Invertebrates were sampled with 10 dip-net sweeps in each pond, and the first ~100 animals were identified (most to family). Phytoplankton abundance was estimated as chlorophyll *a* by filtering, ethanol extraction, and narrow band fluorometry. The growth of algae in the absence and presence of macrograzers was determined by deploying artificial substrates in each pond, and determining chlorophyll *a* concentrations as above after 14 days. Measurements of depth, dissolved oxygen, temperature, conductivity, and pH were taken at five points in each pond, and each pond's circumference was measured. Ponds with higher dissolved oxygen, higher pH, or greater area had greater macroinvertebrate species richness. These ponds were typically in less disturbed landscapes than were small, turbid, high-nutrient farm ponds (cattle watering ponds). Farm ponds typically had greater phytoplankton and periphyton biomass and a greater proportion of pollution tolerant invertebrate taxa such as corixids, chironomids, and oligochaetes.

LETHAL AND SUB-LETHAL EFFECTS OF COPPER ON AN AQUATIC INVERTEBRATE (*LUMBRICULUS VARIEGATUS*). <u>Jason Crolley</u> & Jeremy M. Wojdak, Department of Biology, Radford University, Radford, VA 24142. Copper (and other heavy metal) pollution leaching from the abandoned Toncray Mine in southwest Virginia has been linked to biological impairment of the East Prong of Furnace Creek. To evaluate the efficacy of three remediation ponds built in 1994 to help reduce pollution runoff to the creek, we conducted chemical analyses and laboratory-based toxicological tests using the California Blackworm, *Lumbriculus.variegatus.* Mortality and pulsation rates (an indicator of physiological well-being) of *L. variegatus* were examined after exposure to mine effluent, remediation pond water, water from the creek above and below the mine, and to copper solutions of known concentration. Water from the mine drainage and settling ponds was very toxic, exceeding the US EPA screening value for copper in freshwater by nearly 500 fold, and causing nearly 100% mortality within 48 hours. Mine drainage into the creek had no clear effects on worm pulsation rate or mortality (i.e. comparing upstream vs. downstream). Our data and previous data indicate the ponds effectively removed copper and increased pH in 1998, but not in 2004 or in 2006. Experiments with lower concentrations of copper than found in the mine area indicate that worm pulsation rates decrease with increasing copper concentration.

AN ASSESMENT OF THE WATER QUALITY OF CROOKED RUN, IN FREDERICK, CLARKE AND WARREN COUNTIES, VIRGINIA, BASED ON THEIR FISH POPULATIONS. <u>Lyla H. Gray</u>, Michelle S. Miller, Woodward S. Bousquet & Karen R. Andersen, Environmental Studies Program, Shenandoah

University, Winchester, VA 22601. Located in the northern Shenandoah Valley, Crooked Run is a tributary to the North Fork of the Shenandoah River. Its watershed comprises approximately 30,000 acres. A new 1930-unit housing development in the watershed's upper reaches surrounding Lake Frederick raised local concerns about impacts on the stream's water quality and biological diversity. In cooperation with the Friends of the Shenandoah River (FOSR, a regional citizens organization), and the Virginia Department of Game and Inland Fisheries (VDGIF), the researchers used electroshocking gear to collect fish from nine sites on Crooked Run's main stem and its stream and spring-run tributaries. A total of 1,352 fish of 32 species were captured, identified, weighed and released. The average fish Index of Biotic Integrity (IBI) score of 2.62 revealed that the water quality in the main stem of Crooked Run is only fair. Two wastewater processing facilities will eventually add their contents to this small stream.

MONITORING THE PROGRESS OF A WETLAND MITIGATION PROJECT FOR CENTRAL PARK IN FREDERICKSBURG, VA. Michelle Arthur & Michael Bass, Environmental Science & Geology, University of Mary Washington, Fredericksburg, VA. The purpose of this study was to monitor the ecological development of a series of stormwater management ponds and their accompanying off-site wetland mitigation area which was to replace a destroyed forested wetland. The quality of the ponds and forested wetland site was monitored through chemical testing and a survey of the vegetation present. In addition the distribution of hydric soils was also monitored in the off-site wetland area. The water chemistry parameters measured showed no unusual highly elevated components. Manganese was the highest metal found but was still below the accepted regulated level. Zinc and copper concentrations were well below the limits. In the off-site area the number of woody stems per acre was the important parameter that required monitoring. VDEQ requires 400 stems per acre to meet the guidelines for a successful forested wetland. In 2003 the woody stem count was 557 per acre, in 2004 the woody stem count was 1096. However in 2005 the count had dropped dramatically to 334 woody stems per acre because of wildlife predation, primarily from a beaver. The herbaceous species identification yielded an increase with some new species added and some others from previous years being lost, exhibiting ecological succession.

Medical Science

FGF23 BINDS TO FGFR1 TO DOWNREGULATE 1-ALPHA HYDROXYLASE IN HUMAN PROXIMAL KIDNEY CELLS (HK-2G). Megan Forster & M. J. Beckman. Orthopaedic Surgery and Biochemistry, Virginia Commonwealth University, Richmond, VA, 23298. The 1-alpha-hydroxylase (CYP27B1) is a p450 mitochondrial enzyme that is responsible for the conversion of vitamin D to its active form. CY27B1 is highly expressed in the proximal tubules of the kidney and is regulated by many factors. Parathyroid hormone (PTH), which is released under low calcium conditions, is a key regulator of CYP27B1. PTH up-regulates

CYP27B1 leading to increased 1-α-hydroxylation of 25-OH-D at the carbon one position to form the active form, 1,25-dihydroxyvitamin D_3 (1,25 VD). 1,25 VD has the main role of restoring blood calcium. Recent finding have demonstrated that the novel fibroblast growth factor 23 (FGF23) is responsible to down-regulate CYP27B1 in response to high blood phosphate conditions or increased 1,25 VD. FGF23 is primarily released from the bone, but new evidence shows minor expression from other tissues such as the liver, and spleen. The goal of this study was to demonstrate the expression of FGF23 from renal proximal tubule cells. A human kidney proximal cell line (HK-2G) was used as the model. This study confirmed that PTH follows the PKA/CREB pathway in order to upregulate CYP27B1. Using Real-Time RT-PCR FGF23 and FGF receptor 1 gene expressions were also shown to occur in a time-dependent manner and in response to 1,25VD. In conclusion, this new pathway may represent a short feedback mechanism for modulating the synthesis of CYP27B1 and counteracting its increase by PTH.

CONFORMATIONALLY-CONSTRAINED ANALOGS OF THE ANALGESIC ENHANCING AGENT MD-354. E. O. De Oliveira, S. Young, R. A. Glennon & M. Dukat, Department of Medicinal Chemistry, Virginia Commonwealth University, Richmond VA, 23298-0540.   The severe side effects of the α_2-adrenoceptor agonist clonidine generally limit its use as an analgesic to clinical settings where such effects can be closely monitored. *m*-Chlorophenylguanidine (*m*CPG; MD-354) is an agent that lacks antinociceptive actions of its own in the mouse tail-flick assay (i.e., <5% MPE – maximal possible effect), but is able to potentiate the antinociceptive actions of a low "inactive" dose of clonidine (13% MPE) such that when administered in combination significant (>80% MPE) antinociception is achieved. MD-354 has been shown to be a partial agonist at 5-HT_3 receptors, and elimination of the chloro group results in reduced affinity. To examine conformational preference for the binding of MD-354 at 5-HT_3 receptors, two rotamers of MD-354 (i.e., 7-chloro-3,4-dihydroquinazolin-2-amine (**1**) and 5-chloro-3,4-dihydroquinazolin-2-amine (**2**)) were prepared. Neither of them (i.e., **1** (K_i = 680 nM), **2** (K_i = 4,600 nM)) retained the affinity of MD-354 (K_i = 90 nM). These findings might reflect a lack of tolerance by the receptors for the added methylene group, or indicate that either a specific NH contributes to binding or that some other conformer might be preferred for high affinity. (This work was supported in part by J-778 from the Jeffress Foundation.)
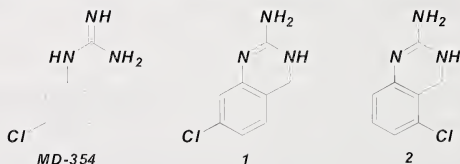
BINDING OF METHOXY-SUBSTITUTED N_1-BENZENESULFONYLINDOLE ANALOGS AT HUMAN 5-HT_6 SEROTONIN RECEPTORS.   R. Kolanos[1], U. Siripurapu[1], M. Dukat[1], B. L. Roth[2, 3] & R. A. Glennon[1], [1]Department of Medicinal Chemistry, Virginia Commonwealth University, Richmond VA 23298 and Departments of [2]Biochemistry, [3]Psychiatry and Neurosciences, Case Western

Reserve University, Cleveland OH 44106. $5\text{-}HT_6$ receptors, one of the seven families of serotonin receptors, are of interest because of their possible involvement in certain neuropsychiatric and neurological disorders. Two series of compounds, N_1-(4-aminobenzene)sulfonylindole and N_9-(4-aminobenzene)sulfonyl-1,2,3,4-tetrahydrocarbazole analogs, were utilized to determine if the effect of methylamine substituents was related to a direct receptor interaction with an amine binding site or whether they simply altered the electronic character of the molecules. Comparison of several amine-substituted indoles with their methoxy-substituted counterparts suggests that these substituents influence $5\text{-}HT_6$ receptor affinity indirectly *via* their electronic effect on the indolic nucleus. The amine-substituted and methoxy-substituted tetrahydrocarbazole counterparts, despite their structural similarity to N_1-(4-aminobenzene)sulfonylindoles, do not behave in the same manner; introduction of methylamine or methoxy substituents was not well tolerated and tended to decrease $5\text{-}HT_6$ receptor affinity. Overall then, the presence of the methoxy group results in slightly enhanced affinity compared to unsubstituted and amine-substituted indoles but not tetrahydrocarbazoles, 4,6-dimethoxy-N_1-(4-aminobenzene)-sulfonylindole (K_i=0.8 nM) was found to bind with very high affinity at $5\text{-}HT_6$ receptors, and the indolic substituents likely influence affinity *via* their electronic effect on the indole nucleus. [Supported by MH-60599]

PHENYLALKYLAMINE BENZENESULFONAMIDES AS $5\text{-}HT_6$ RECEPTOR LIGANDS. D.M.N. Sikazwe[1], M. Dukat[1], B.L. Roth[2], & R.A. Glennon[1], [1]Dept. of Medicinal Chemistry, Virginia Commonwealth University, Richmond VA 23298 and [2]Depts. of Biochemistry, Psychiatry and Neurosciences, Case Western Reserve University, Cleveland OH 44106. Human $5\text{-}HT_6$ receptors have been implicated in several types of neurological disorders. We previously reported sulfonyltryptamine MS-245 (**1**; K_i = 2.9 nM) among the first $5HT_6$ antagonists. We now report the synthesis, binding affinities, and structure-activity relationships (SAR) of a series of phenylalkylamine benzenesulfonamides and their sulfone derivatives. The agents were designed to test the hypothesis that sulfonamide-containing arylalkylamines bind to $5HT_6$ receptors in an extended, ergoline-type conformation. If so, compounds such as **2** and **3** should retain affinity. The new derivatives displayed affinities (K_i values) for human $5\text{-}HT_6$ receptors ranging from 15 to 70 nM. It appears that neither an intact sulfonamide moiety (*to wit:* sulfones) nor the position (i.e., 3- *vs* 4-position) of the sulfonamide, nor exchanging a phenylakylamine with a structurally simpler pyrroloethylamine (i.e., **3**; K_i = 15 nM), alters binding significantly. The results indicates that these ligands bind to human $5\text{-}HT_6$ receptors in a similar, ergoline-type fashion, and provide a comprehensive model for the binding of multiple classes of 5-HT_6 receptor ligands. [Supported by MH-60599.]

1 R = SO$_2$Ph 2 R = -NHSO$_2$Ph, -SO$_2$NHPh, -SO$_2$Ph 3 R = SO$_2$Ph
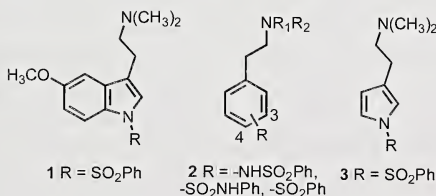
ARYLOXYETHYLAMINES: BINDING AT 7 NICOTINIC CHOLINERGIC RECEPTORS. H.M. Ragab[1], J.S. Kim[1], M. Dukat[1], H. Navarro[2] & R.A. Glennon[1], [1]Department of Medicinal Chemistry, Virginia Commonwealth University, Richmond VA 23298 and [2]Research Triangle Institute, NC 27709. α7-Nicotinic cholinergic (nACh) receptors are the second most abundant population of nicotinic receptors in brain after α4β2 nACh receptors. Very little is known about them but they are of interest because of a possible role in cognitive and perceptual disturbances. Gotti et al., reported that certain choline ethers (**1**; R=styryl, R'=CH$_3$ and X=CH) are α7-selective anatagonists with little affinity for β2 containing nACh receptors. Because we have previously developed 6-(2-phenethyl)nicotine (6-PEN) and APXQ (**1**; R=R'=H, X=N) as nicotine ligands, and because the choline ethers might be viewed as an amalgamation of 6-PEN and APXQ, we examined the structure-affinity relationship for α7 binding. We examined several aryloxyalkylamine analogs to determine the role of various structural features for binding at homomeric α7 nACh receptors. In general, the presence of R = phenyl or styryl had little influence on affinity and the ring N atom might contribute to affinity but is not essential. In contrast, the N,N,N-trimethyl quaternary amine is a major contributor to α7 binding. [Funded in part by DA 05274 and the Egyptian Channel Program].

THE SIGNALING PATHWAYS INVOLVED IN ACTIVATION OF VITAMIN D RECEPTOR REGULATION IN HUMAN PROXIMAL KIDNEY CELLS (HK-2G). Aparna Maiti[2] & M. J. Beckman[1,2]. Orthopaedic surgery[1] and Biochemistry[2], Virginia Commonwealth University, VA, Richmond 23298. The vitamin D Receptor (VDR) is a steroid nuclear transcription factor responsible for mediating the biological activities of 1,25-dihydroxyvitamin-D$_3$. Renal VDR content is an important factor in calcium homeostasis, and vitamin D inducible target genes. In these tissues, VDR expression is highly regulated by calcium level in the body. However, the signaling connection between extracellular calcium mediated VDR up-regulation is not been well studied. Here we report that calcium sensing receptor (CaSR) expressed endogenously in renal proximal tubules, is involved in VDR up-regulation in response to high extracellular calcium $[Ca^{2+}]_e$, following p38 mitogen activated protein kinase (MAPK) pathway. Western Blot results demonstrated that 3mM $[Ca^{2+}]_e$ calcium triggers VDR activation within 1h, reached maximum at 6-18h, and declined after 24h. High $[Ca^{2+}]_e$ activated both ERK1/2 and P38 phosphorylation, however specific p38 inhibitor at the dose of 10μM, abolished VDR induction. Essential role of CaSR is demonstrated by using gadolinium a known agonist, and further confirmed by using G-protein inhibitor, pertussis toxin, and PLC inhibitor, U73122. Pertussis toxin did not inhibit high $[Ca^{2+}]_e$ mediated VDR up-regulation explains that CaSR is involved in Gq coupling system. This new evidence demonstrates how extracellular Ca plays a direct role in restoring cell-specific responsiveness of the kidney proximal tubule to effects of 1,25-dihydroxyvitamin-D$_3$.

ISOLATION OF MESENCHYMAL STEM CELLS DERIVED FROM ADULT BONE MARROW AND UMBILICAL CORD BLOOD AND THEIR POTENTIAL TO DIFFERENTIATE INTO OSTEOBLASTS. Andrew P. Pacitti[3], K. Wartella[4], J. Wayne[4], E. Mainali[2] & M. Beckman[1,5], Depts. of [1]Orthopaedic Surgery, [2]Pediatrics, [3]Physiology, [4]Biomedical Engineering, and [5]Biochemistry, Virginia Commonwealth University, Richmond VA 23298. Mesenchymal stem cells (MSCs) are defined as pluripotent progenitor cells with the ability to generate cartilage, bone, muscle, tendon, ligament and fat. These cells have generated tremendous interest in their potential use to replace damaged tissues. Mesenchymal stem cells can be cultured to expand their numbers then transplanted to the injured site after seeding on biomimetic scaffolds to generate appropriate tissue constructs. An alternative approach for skeletal repair is the selection, expansion and modulation of osteoprogenitor cells in combination with a conductive scaffold together with appropriate bone growth factors to support and guide regeneration. We have focused on the isolation of mesenchymal stem cells derived from both adult bone marrow (ABM) and umbilical cord blood (CB) using a novel isolation technique based on the positive and negative selection of specific stem cell surface markers. These cells were induced to differentiate into mature bone producing osteoblast cells, which was confirmed using the techniques of RT-PCR, von Kossa staining, and confocal microscopy. Our results confirmed that highly homogenous MSC populations from both ABM and CB tissues were able to be obtained by an immuno-depletion method and that these cells were also capable of maintaining their stem cell nature until induced down a distinct cell lineage.

TEMPO AND REGULATION OF IFNG PRODUCTION IN EXPERIMENTAL RSV INFECTION. L. M. Pujanauski[1], W. W. Stevens[2,4], J. P. Castillo[2] & T. J. Braciale[2,3,4], [1]Dept. Of Biology, [2]Beirne B. Carter Center for Immunology Research and Depts. Of [3]Pathology and [4]Microbiology, UVA. In previous efforts to develop a vaccine for Respiratory Syncytial Virus (RSV), infants vaccinated with Formalin-Inactivated RSV who were later naturally infected with RSV developed enhanced pulmonary injury. Murine models have been developed to show that mice vaccinated with the G protein of RSV and then challenged with RSV also developed pulmonary eosinophilia and a memory (m) CD4 T cell Th2 response with no mCD8 T cell response. Mice vaccinated with the M2 protein and then challenged with RSV produced no eosinophilia, a mCD8 T cell response, and a yet to be characterized mCD4 T cell response. In RSV-infected mice that were vaccinated with both the G and M2 proteins, no eosinophilia was observed while both a mCD4 and mCD8 T cell response was generated. These studies suggest that mCD8 T cells are modulating mCD4 T cells away from a Th2 response, preventing eosinophilia. IFNg is a cytokine secreted by activated mCD8 T cells and has been shown to prevent the development of a Th2 response. As a result, it is hypothesized that IFNg produced by mCD8 T cells could drive mCD4 T cells away from a Th2 response, thus preventing pulmonary eosinophilia. In order to test for the presence of IFNg, IFNg ELISAs were performed on lung samples from M2-primed RSV-infected mice. IFNg was detected in the lungs during the first 4 days following RSV

infection in M2-primed mice, but not seen in control mice. These results indicate that IFNg is present in the lungs of M2-primed RSV-infected mice and could potentially cause mCD4 T cells to differentiate away from a Th2 response.

THE EXPRESSION OF RANKL BY FIBROBLASTS WITHIN THE PERIPROSTHETIC MEMBRANE. Samuel C. Ramage[3], Patrick E. Jones[2], William A. Jiranek[1] & Matthew J. Beckman[1,3], Departments of Orthopaedic Surgery[1], Anatomy[2] and Biochemistry[3], Virginia Commonwealth University, 23298. Aseptic osteolysis is the loss of bone surrounding a total joint replacement. This results in implant loosening and usually requires costly total joint revision surgery. A periprosthetic membrane composed primarily of fibroblasts and macrophages is usually found between the bone and implant surfaces at the site of resorption. Previous work in our lab has shown that the cytokine known to promote osteoclast activation, RANKL, is present at high levels in areas bone resorption and shows cellular expression patterns closely related to fibroblasts. We investigated this expression pattern using confocal microscopy and a variety of fibroblasts markers as well marker for other cell types. We saw strong colocalization of several fibroblast markers with RANKL and a lack of co-localization with the myeloid markers used. In addition, our study showed in all patient samples examined there was a large multinuclear cell or collection of cells that showed fibroblast markers as well as extremely high levels of RANKL.

ROLE OF SPP-24 AND RHBMP INTERACTION IN OSTEOBLAST CALCIFICATION. James M. Silcox, Samuel C. Ramage, Joanna Jeruzal, & Matthew J. Beckman, Departments of Orthopaedic Surgery, Anatomy, & Biochemistry, Virginia Commonwealth University, Richmond VA 23298. Marshall Urist first isolated what he called non-collagenous protein/bone morphogenetic protein (NCP/BMP) nearly forty years ago that caused ectopic bone formation. This was a mixture of proteins that included the now widely characterized bone morphogenetic protein (BMP) family. However, Urist has said that he believes what has been characterized so far is not responsible for the original NCP/BMP activity he observed. Behnam et al., based off of Urist's observations, produced a synthetic peptide that corresponds to a 19-amino acid sequence of secreted phosphoprotein 24 (Spp-24). This peptide has the characteristics of the peptide that Urist first described and attributed NCP/BMP activity. When used in conjuction with BMP-2, their synthetic peptide increased the over-all osteogenic activity of rhBMP-2, reduced the time required for rhBMP-2 to induce ectopic bone formation, and induces calcification by itself. We have taken the entire spp-24 gene, and ligated it into a FLAG vector. We then transfected osteoblasts (MG-63) with the vector, and treated the cells with 0, 5, and 50 $^{ng}/_{ml}$ of rhBMP-2 three days after transfection. We let the cells grow for three days after treatment, and then performed von Kossa staining on each treatment. We were able to see significantly higher amounts of calcium deposition in the cells treated with spp-24 and rhBMP-2 as opposed to the cells that were treated with just rhBMP-2 or just spp-24.

THE EFFECTS OF CANNABIDIOL, A CONSTITUENT OF MARIJUANA, ON THE DISCRIMINATIVE STIMULUS AND CONDITIONED PLACE AVERSION EFFECTS OF Δ^9-THC. Thomas F. Gamage, Robert E. Vann, Jonathan A. Warner, Ericka M. Marshall, Nathan L. Taylor & Jenny L. Wiley, Dept of Pharmacology VCU, Richmond, VA, 23298. Sativex, a drug containing equal parts of Δ^9-tetrahydrocannabinol (THC) and cannabidiol (CBD) has recently been approved in Canada for the treatment of multiple sclerosis. CBD's subjective effects and reward-related stimulus as they occur in marijuana, at various ratios to THC, or in Sativex, at a 1:1 ratio, have yet to be studied. This study examined the effects of CBD on THC's discriminative stimulus effects in Long Evans rats trained to discriminate THC from VEH in a two lever drug discrimination paradigm. In addition, the effects of CBD on contextual cues associated with THC's stimulus effects were studied using the conditioned place preference/aversion (CPA) model in ICR mice. In the drug discrimination study, CBD failed to substitute for THC and did not alter its subjective effects at any ratio tested. During the CPA tests, CBD alone had no effects. In contrast, a 10 mg/kg dose of THC alone produced aversion whereas lower doses produced neither aversion nor preference. When administered in combination in a 1:1 ratio as found in Sativex, CBD (10 mg/kg) attenuated the aversive effects 10 mg/kg THC, but had no effects on lower doses of THC. In conclusion, CBD does not alter THC's discriminative stimulus effects, but it may alter THC's aversive effects. In addition, this research supports a view that the combined effects of cannabinoids such as CBD and THC may elicit different effects than when THC is administered alone. Research supported by NIDA grants DA-09789 and DA-03672.

THE GENETIC ANALYSIS OF ETHANOL-INDUCED ANXIOLYSIS IN BXD RECOMBINANT INBRED MICE. Alexander H. Putman & Michael F. Miles, Dept. of Pharmacology & Toxicology, Virginia Commonwealth University, Richmond VA 23298. Due to the high comorbidity between anxiety and ethanol abuse, there has been a long-standing interest in understanding the relationship between these two disorders. Although anxiety is hypothesized as a factor in the initiation of ethanol abuse and risk for relapse, the molecular mechanisms underlying anxiety, ethanol addiction, and their correlation are not well understood. The identification of ethanol-induced anxiolysis-like behavioral quantitative trait loci (QTL) will aid in understanding the neurobiology of ethanol-induced anxiolysis. Therefore, anxiety-related responses to ethanol were measured across the BXD recombinant inbred panel and C57BL/6J (B6) and DBA/2J (D2) progenitors using the light-dark transition model of anxiety. The progenitor strains exhibited a robust anxiolytic-like response following 1.8g/kg ethanol while preliminary QTL analysis identified potential genetic loci associated with various anxiety-related behaviors. A significant basal anxiety QTL mapped to chromosome 11 and a significant chromosome 12 QTL may influence the susceptibility to ethanol-induced anxiolysis. Additional analyses will include the identification of ethanol-responsive expression patterns in the prefrontal cortex (PFC) across the BXD recombinant inbred panel using Affymetrix oligonucleotide microarrays and identify expression QTL. This approach will allow us to correlate expression

patterns with behavioral data, ultimately aiding in defining the molecular mechanisms involved in ethanol-induced anxiolysis. Supported by NIH Grants AA013678, AA014717 to MFM and AA016052 to AHP.

ALTERATIONS OF THE IMMUNE SYSTEM DURING CRITICAL STAGES OF DEVELOPMENT FOLLOWING EXPOSURE TO 1,2:5,6 DIBENZANTHRACENE (DBA) IN B6C3F1 MICE. Denise M. Hernandez & Kimber L. White, Jr., Virginia Commonwealth University, Richmond, VA. DBA is an environmental contaminant classified on EPA's priority pollutant list and is formed by the incomplete combustion of carbon containing compounds. The objective of these studies was to evaluate the immunosuppressive effects of DBA in adult and juvenile B6C3F1 mice to determine whether exposure at different windows of development causes enhanced immunotoxicity. Juvenile mice were dosed beginning on postnatal day 21 (+/- 2 days) with DBA in corn oil (79.3, 250, 793, and 2500 ug/kg) subcutneously for 28 days. Adult animals were dosed beginning at 8-10 weeks of age and received similar and higher doses up to 5000 ug/kg. Several immune parameters including the IgM antibody forming cell response, Natural Killer cell activity, and anti-CD3 antibody-mediated proliferation assay were used to evaluate humoral, innate and cell-mediated immune competence. These studies will provide insight into how environmental agents may impact the developing human immune system.

TIME COURSE OF THE ENHANCEMENT AND RESTORATION OF THE ANALGESIC EFFICACY OF CODEINE AND MORPHINE BY [9]-TETRAHYDROCANNIBINOL. I. Jovan Williams, Sherita Edwards, Alex Rubo, Victoria L. Haller, David L. Stevens & Sandra P. Welch, Dept. of Pharmacology and Toxicology and School of Nurse Anesthesia, Virginia Commonwealth University Medical College of Virginia, Richmond VA 23298. Δ^9-tetrahydrocannabinol (Δ^9-THC) synergizes with morphine and codeine by releasing endogenous opioids. These studies determined 1) the duration of enhancement of morphine and codeine by Δ^9-THC, 2) the effect of Δ^9-THC on the time course of fully efficacious doses of opioids, 3) restoration of efficacy of morphine and codeine by Δ^9-THC, and 4) duration of restoration. Sub-active combination doses of Δ^9-THC/morphine or Δ^9-THC/codeine are equivalent in duration of action and efficacy to high-dose opioids alone. Δ^9-THC (20mg/kg p.o.) significantly restores the antinociceptive effects of both high-dose morphine and codeine (100 and 200 mg/kg p.o., respectively) at later time points at which morphine or codeine was no longer active (360- and 120-min post-administration, respectively). Thus, the cannabinoid/opioid combination might be useful in therapeutics to enhance opioid activity, as well as to restore the efficacy of opioids.

DESIGN OF A HUMAN HEART TRANSPORT UNIT. K. Garland[1], G. Horton[1], J. Olsen[1], E. Roesch[1], R. Grisso[1], R. P. Wyeth[2] & the Via Virginia College of Osteopathic Medicine, Cardiac Transplantation Group[1, 2]. [1]Virginia Polytechnic Institute and State University, Blacksburg, VA 24061. [2]Edward Via Virginia College of Osteopathic Medicine, Blacksburg, VA 24060. The inability to extend

cold ischemic storage time during transport is the primary factor in loss of donated hearts before they can be used. We have designed a small self-contained portable heart transportation unit that will increase storage time of explanted hearts. All elements, devices, and perfusate, in addition to the donor heart, are contained in a lightweight, ergonomic, durable unit of three layers; an inner and outer layer of polypropylene and a middle layer of polyurethane foam. The transport unit is designed with monitoring devices for flow, temperature, oxygen level, pH, and pressure. It will store 5.0 L of perfusate, a discharge bag, and a container with the perfused heart surrounded by a small amount of superfusate. The unit will contain a piezoelectric heating/cooling device, pressure monitoring transducers, a pH and O_2 sensor, a variable flow metering pump and a dedicated microprocessor to integrate and control temperature, pressure, flow rate, pH and O_2 tension of the donor heart. The unit will be modular. It will have a small ledge attached to the bottom of the unit. The battery, pump controller, dual pressure indicator, and multifunction meter will be fastened to this ledge. The final design follows regulations set forth by the FAA, DOT, EPA, and FDA. In conclusion, a compact, lightweight cardiac transport unit has been designed to increase the storage time of explanted donated hearts. This design allows for continuous perfusion of myocardium and careful monitoring and adjustment of O_2 tension, pH and temperature. This design could significantly reduce, or eliminate ischemic time in explanted hearts. Thus, this devise will significantly increase the number of donor hearts suitable for transplantation.

ALTERATIONS IN EXCITATORY AND INHIBITORY NEUROTRANSMISSION FOLLOWING MILD MECHANICAL INJURY. J.G. Pope, P.B. Goforth & L.S. Satin, Department of Pharmacology & Toxicology, Virginia Commonwealth University Medical Center, Richmond VA 23298. Traumatic brain injury (TBI) is a major health problem and a leading cause of death in individuals under 30. TBI leads to impaired cognitive and motor function, and may result from changes in inhibitory GABAergic, as well as excitatory glutamatergic synaptic transmission. Spontaneous, non-action potential driven miniature inhibitory postsynaptic currents (mIPSCs) and miniature excitatory postsynaptic currents (mEPSCs) were recorded in control and mildly stretch injured cultured cortical pyramidal neurons. Both mEPSCs and mIPSCs provide a simple and direct method to examine the function of postsynaptic glutamate and $GABA_A$ receptors respectively. Neurons were injured using a controlled puff of air produced with an injury control device to simulate forces that occur during mild brain concussion. This study shows that mild mechanical injury reduces mEPSC amplitude, slows their rise time and increases their half width. Longer mEPSC duration would be consistent with an increase in NMDA receptor contribution to the synaptic event possibly due to the relief of Mg^{2+} block after injury and/or reduced AMPA receptor desensitization, both found in previous studies by our lab. In opposition to the findings for injury induced changes in mEPSCs, this study shows injury increases mIPSC amplitude, yet does not significantly alter their rise time or their half width. The change in mIPSC amplitude observed following injury is possibly due to phosphorylation of $GABA_A$ receptors by CAMKII, whose activity

has been found to increase after injury by our lab, possibly due to increased intracellular free calcium.

TOLERANCE TO THE IMMUNOSUPPRESSIVE EFFECTS OF Δ^9-THC IN B6C3F1 MICE. Chris M. Sheth & Kimber L. White Jr., Dept. of Pharmacology and Toxicology, Virginia Commonwealth University, Richmond, VA 23298. Δ^9-Tetrahydrocannabinol is isolated from *Cannabis sativa* and is responsible for its psychotropic effects. In the CNS, tolerance to THC's effects has been observed. We have seen a similar phenomenon in the immune system. Cell mediated immunity was evaluated in the delayed type hypersensitivity (DTH). 14 Days of THC exposure at 50 mg/kg suppressed the DTH response 43% compared to controls. With mice treated for 30 days responding identically to control mice. Our objective was to investigate THC's ability to produce immunologic tolerance using other functional assays. Mice were treated for 5, 14, or 28 days and were evaluated with the AFC response to the T-dependent antigen sRBC. Five days of dosing resulted in 47% suppression compared to controls. However, mice treated with for 14 or 28 days were suppressed 18% and 7%. To determine if the tolerance could be overcome, mice were treated for 14 days at 50 mg/kg and then at 200 mg/kg for an additional 4 days, which resulted in a 52% suppression, similar to the 5 day response. Tolerance was also demonstrated in the anti-CD3 mediated proliferation assay. At 6 hours post exposure the response was suppressed by 96%. However, there was no difference in the proliferative response in mice treated for 5 days when compare to vehicle controls. Following short periods of exposure THC is immunosuppressive; however, tolerance appears to develop after prolonged administration.

COMPARISON OF ACUTE OPIOID DEPENDENCE IN THREE RAT STRAINS. Richard W. Morgan, Robert L. Balster & Katherine L. Nicholson, Dept. of Pharmacology & Toxicology, Virginia Commonwealth University, Richmond VA 23298. Opioids are still among the most effective and widely used analgesic agents. Unfortunately, their clinical usefulness can be hindered by the development of physical dependence. While most models investigating physical dependence rely on chronic administration of opioids the Acute Opioid Antagonist Sensitization (AOAS) model can produce signs of withdrawal upon administration of an opioid antagonist (naltrexone) after a single dose of an opioid agonist (morphine) administered 4-hours earlier. Previous studies have used Sprague Dawley rats to demonstrate this phenomenon. The current study compares acute dependence in the outbred Sprague Dawley strain to the inbred Lewis and Fischer 344 strains. The latter two strains have been shown to have differing responses to opioid agonists. Relative to the other strains, Fischer 344 rats appeared to be more sensitive to the rate decreasing effects of naltrexone alone. While all three strains demonstrated sensitization to naltrexone following morphine, the degree of sensitization appeared greatest in the Lewis rats and least robust in the Fischer 344 rats. The ultimate goal of the study is to compare the ability of drugs from different classes to attenuate the development of acute dependence in the three strains, therefore, we have also completed dose effect curves in a separate group of Sprague Dawley rats showing

the ability of naloxone pretreatment to block the development of acute dependence. This work was supported by NIDA grants DA 01442 and DA 07027-30.

THE EFFECT OF TETRAETHYLAMMONIUM CHLORIDE ON THE KINETICS OF OSMOTICALLY-INDUCED HEMOLYSIS OF MAMMALIAN RED BLOOD CELLS. James W. Pickens & Stephen Gallik, Dept. of Biology, University of Mary Washington, Fredericksburg, VA. 22401. The specific objectives of this study are to describe the kinetics of osmotically-induced hemolysis of sheep red blood cells and the effect of tetraethylammonium chloride (TEA) on those kinetics using a comprehensive curve-fitting analysis designed to determine the simplest equation(s) that best describe the hemolytic process. The hemolysis of normal and TEA-treated sheep erythrocytes was tracked across a series of four hypotonic phosphate-buffered saline (PBS) solutions ranging from 0.40% to 0.55% PBS. The percent transmittance of 625nm light (%T625), used as a measure of the amount of hemolysis, was recorded continuously over a period of three minutes. The results show that the process of osmotically-induced hemolysis of sheep red blood cells can be described equally well by any one of five relatively simple kinetic equations, the simplest of the five being a second-order hyperbolic equation of the form $y = (ax) / (b+x)$, where a is the maximum %T625 (max % hemolysis) attained in the reaction and b is the time required to reach half-maximum %T625. The results also show that the initial instantaneous velocity of hemolysis of sheep red blood cells falls within a range of approximately 16 %T625/sec for cells submerged in 0.40% PBS to approximately 1.4 %T625/sec for cells submerged in 0.55% PBS. In addition, the results show that TEA, at concentrations of 62.5 mM and 125 mM, significantly reduces the initial instantaneous velocity of hemolysis in these four hypotonic solutions.

Natural History & Biodiversity

TREES, TURTLES AND FISH: ASSESSING THE ECOLOGY OF THE CEDAR CREEK WATERSHED IN FREDERICK, SHENANDOAH AND WARREN COUNTIES, VIRGINIA. Woodward S. Bousquet, Lyla H. Gray, E. David Kocher, Arturo Oliverosamador & Gregory N. F. Spangler, Environmental Studies Program, Shenandoah University. Cedar Creek's watershed, part of the Shenandoah River drainage, is situated in the northern Shenandoah Valley and encompasses an area of approximately 157 square miles. Six sites for assessing fish assemblages and nine sites for describing terrestrial communities were selected to represent a diversity of ecological situations and geographic locations. Fish were electroshocked and released. Terrestrial communities were documented through the relevé procedure, which emphasizes physical features and vegetation. Thirty fish species in 8 families were collected. The average fish Index of Biotic Integrity (IBI) score of 4.25 showed that the creek's main stem is relatively clean and not degraded. Although a complete botanical survey was beyond the project's scope, this investigation, with additional data provided by Gary Fleming, Virginia Division of Natural Heritage (DNH), revealed 12 vascular plants not previously recorded for Frederick County

and 4 species new to Shenandoah County. Seven ecological communities were named using the DNH's classification system. Findings establish the watershed's environmental quality and biodiversity, providing a basis for its protection and management. (Supported by: Potomac Conservancy through the Potomac Watershed Partnership, the Virginia Foundation for Independent Colleges, and donations to Shenandoah University for environmental research, outreach and service-learning.)

THE 2005 VIRGINIA SOCIETY OF ORNITHOLOGY BREEDING BIRD FORAY IN RUSSELL AND WISE COUNTIES. Andrew S. Dolby, Dept. of Biological Sciences, University of Mary Washington, Fredericksburg VA 22401. The 2005 Virginia Society of Ornithology Breeding Bird Foray was conducted June 4-12 in Russell and Wise Counties. Twelve participants recorded species richness and abundance by both auto and foot. While effort was spread throughout Russell County, Wise County's high elevation High Knob Recreation Area and heavily forested Guest River Gorge were targeted. For both counties combined, 114 species were reported, representing 13 orders and 37 families. European Starlings were most abundant, followed by Common Grackles and American Robins. For 11 species, only one individual each was reported. Blue Jays were found along the greatest number of survey routes. In general, edge and disturbance-tolerant species predominated in Russell County, but more forest interior and high elevation species were detected at the Wise County sites. Direct signs of breeding activity were observed for 52 species, from sightings of male-female pairs to active nests containing viable nestlings. Similar species totals were reported during several previous southwestern Virginia forays spanning 1966 through 1992. However, many species were at far lower abundance in 2005. This apparent reduction in abundance may be attributable to habitat loss in both breeding and non-breeding ranges. Several species consistently detected during previous surveys in the region, but absent in 2005, were united by their dependence on spruce-fir forest. It is hypothesized that continued decline of this habitat type in the southern Appalachians has resulted in regional reductions in their populations, thus decreasing their overall likelihood of detection.

LARGE MAMMAL DISTRIBUTION, TRAP SUCCESS, AND HABITAT USE DETERMINED BY REMOTELY TRIGGERED INFRA-RED CAMERAS ON SALT POND MOUNTAIN, GILES CO., VA. Erika L. Holub & Marcella J. Kelly, Dept. of Fisheries and Wildlife Science, VPI & SU, Blacksburg VA 24061. In order to evaluate trap success across species and among camera types as well as predict occurrence of target species, we established 15 remotely triggered infra-red camera stations across a 27 km² study area comprised of Jefferson National Forest land, Mountain Lake Biological Station (MLBS) land, and other private land in Giles Co., VA. We monitored camera stations for 83 days (August to October 2005) for a total 891 trap nights (TN). Overall trap success for all animals combined was 51 per 100TN. As expected, white-tailed deer (*Odocoileus virginianus*), had the highest trap success (21.32) followed by all the target carnivores black bear (*Ursus americanus*) (1.97), coyote (*Canis latrans*) (1.01), bobcat (*Lynx rufus*)

(1.46), and gray fox (*Urocyon cinereoargenteus*) (0.67). Passive camera units had higher trap success than active camera units and digital cameras performed better than film cameras. We extracted percent cover type from a geographic information system (GIS) using circular buffers around each trap site and we determined the distance from each station to the main access road. Deer were common and showed little habitat preference. Black bears and coyotes exhibited a tendency to avoid coniferous forest, but only bobcats showed significant avoidance of coniferous forest and had higher trap success the further stations were away from the main access road. This study highlights the potential to use camera traps for numerous wildlife species (particularly carnivores) and to combine camera-trapping with GIS to predict animal occurrence across a landscape.

AN EXAMINATION OF FEED QUANTITY AND FEED QUALITY FOR *EPIOBLASMA SPP.* HELD AT WHITE SULPHUR SPRINGS NATIONAL FISH HATCHERY, WEST VIRGINIA. A. L. Bush[1], S. R. Craig[1], C. M. Gatenby[2], D. A. Kreeger[3] & R. J. Neves[1], [1]Dept. of Fisheries and Wildlife Sciences, Va. Polytechnic Inst. & State Univ., Blacksburg VA 24061, [2]White Sulphur Springs National Fish Hatchery, White Sulphur Springs WV 24986 and [3]Partnership for the Delaware Estuary, Wilmington DE 19801. Recovery of federally endangered oyster mussel (*Epioblasma capsaeformis*), northern riffleshell (*Epioblasma torulosa rangiana*), and Cumberlandian combshell (*Epioblasma brevidens*) depends upon present efforts to successfully propagate and rear juveniles, and hold adults in a captive environment. An understanding of food quantity and food quality requirements for *Epioblasma spp.* is vital to successful captive care. Neither an optimum food quantity, nor specific food quality requirements have been identified for adults of these species. An optimum feed ration for adults fed green-algae (*Neochloris oleoabundans*) will be determined via measurements of clearance rate and absorption efficiency. Clearance rates were measured for oyster mussel, northern riffleshell, Cumberlandian combshell, and snuffbox (*Epioblasma triquetra*). Average clearance rates among species ranged from 1.1 to 1.6 mg h^{-1} g^{-1} of wet mussel tissue. Clearance rates for all species were highest when fed a ration of 80,000 cells ml^{-1}. Diet quality will be examined by targeting seasonal protein demand of specimens. Oyster mussels will be fed low or high protein diets of *N. oleoabundans* for 3 weeks in spring, summer, and fall 2006. O/N ratio will be measured before and after trial diets to assess seasonal protein demand.

LEAF MOVEMENT AND LEAF DAMAGE IN *CERCIS CANADENSIS*: DO LEAVES ACT DIFFERENTLY IN THE SUN AND SHADE? A. Smith & A. B. Griffith, Dept. of Biological Sciences, University of Mary Washington, Fredericksburg VA 22401. Past research has shown that plants growing under different light conditions (direct light, full shade, and partial shade) differ in photosynthetic rates. Two other processes, heliotropism and leaf damage, may lead to photosynthetic differences in sun and shade. Our objective was to measure leaf movement and leaf damage in different light conditions for *Cercis canadensis*. Forty plants were sampled from four sites. At each site five plants were in the sun and five in the shade. Leaf orientation (azimuth and altitude) and leaf damage were

measured on ten leaves. We found differences in leaf orientation of light and shade plants. Leaves in direct light oriented in the same direction while leaves in the shade oriented randomly. The percent of leaves damaged / plant was significantly different between light environments (F = 5.5 p = .026) and between sites (F= 9.0, p = <.001). There was also an interaction between sites and light environment (F = 4.4 p = .011). The percent of damage / leaf was significantly different between light environments (F=31.69, p<0.001) and between sites (F=6.28, p<0.001). Plants growing in a shaded environment tend to have a greater, amount of leaf damage per plant and per leaf than those in the full sun. Our results show that leaf damage is more prevalent in cool, damp environments. It is likely that disease is more damaging to photosynthesis in these conditions than in full sun.

INSECT HERBIVORES OF *AILANTHUS ALTISSIMA* (TREE OF HEAVEN) IN VIRGINIA AND THEIR POTENTIAL AS BIO-CONTROL AGENTS. Shicai Yan, T.J. McAvoy, S.G. Salom & L. T. Kok. Dept. of Entomology, Va. Polytechnic Inst. & State Univ., Blacksburg VA 24061. *Ailanthus altissima* (tree of heaven) is a deciduous woody tree introduced from China to North America in 1800s'. Currently, it has dispersed into 41 of the United States and is regarded as a pest weed. Our monthly surveys in nine sites around Virginia in 2004 and 2005 revealed that native insect herbivores have little impact on *A. altissima* and their potential utilization as biological control agents is minimal. The majority of herbivores we collected are foliage feeders with broad host range and low abundance. *Ailanthus* webworm, *Atteva punctella* Cramer, is the only herbivore species consistently present in all sites. It caused 50% or more defoliation for one-year aged seedlings, while less than 5% defoliation on larger trees (>3 cm diameter) with no visible impact. The only woodborer is ambrosia beetle, *Scolytinae* spp., which is collected from isolated dying trees. Their effects on health *A. altissima* are unknown.

EFFECT OF SIZE AND TEMPERATURE ON OXYGEN CONSUMPTION IN THE HISSING COCKROACH (*GROMPHADORHINA PORTENTOSA*). Jeffrey W. Streicher & Geoffrey F. Birchard, Department of Environmental Science & Policy, George Mason University, Fairfax VA. 22030-4444. *Gromphadorhina portentosa* (Blatteria: Blaberidae) is a cockroach species from tropical Madagascar. Despite its commercial popularity and availability, no physiological research has been conducted on this species. Herein we present the first examination of the rate of metabolism in relation to body mass and temperature in *G. portentosa*. Oxygen consumption rate of nymph and adult cockroaches (n=95) temperature acclimated to 28°C ranging in mass from 0.06-10.61g was measured. The relationship between body mass and oxygen consumption rate was shown to be highly significant (*P=0.0000*). Oxygen consumption rate scaled with an exponent of 0.51, which is lower than the values previously reported for insects. The oxygen consumption rate was also measured at four different temperatures over the range of 16-34°C. An analysis of covariance showed that the oxygen consumption rate decreased with temperature (*F_3=50.56, P=0.0000*). Q_{10} values were determined between each of the temperature classes. Q_{10} values ranged between, 1.651-4.458. An arrhenius plot

of these data indicates a possible break in the relationship for *G. portentosa* between 21 and 16°C. This break along with observed behavioral reactions may indicate the onset of cold torpor around 16°C which would be consistent with the tropical ecology of *G. portentosa*.

A SURVEY OF FLORA AND FAUNA AT HANOVER WAYSIDE PARK HANOVER COUNTY, VA. R.A. Hawkins, K.D. Arnold, & R.S. Groover, Biology Department, J. Sargeant Reynolds Community College, Richmond VA 23285. As the ecology component of a Biology 102 class, a survey of flora and fauna at Hanover Wayside Park in Hanover County, VA was conducted in April of 2006. Eight teams collected data on located flora and fauna in the Park. The survey will be presented to the County as a community service project, to assist with upcoming environmental assessments. The list of identified species include: 17 tree species were located, 9 fungi and lichen; 30 shrubs, grasses and other plants; 15 mammal species, 18 birds; 6 reptiles and amphibians; 12 arthropods: and 20 protists. Species found were typical of a temperate deciduous forest, with no rare, threatened or endangered species found.

SYSTEMATICS OF OPISTHOBRANCH MOLLUSKS FROM THE EASTERN SHORE OF VIRGINIA (MOLLUSCA: GASTROPODA: OPISTHOBRANCHIA). Sara G. Lawrence & Deirdre Gonsalves-Jackson, Dept. of Biol., Randolph-Macon Woman's College, Lynchburg VA. 24503. Few studies exist documenting the diversity of opisthobranch mollusks (sea slugs) from the Eastern Shore of Virginia. To date only 21 species have been recorded. The goals of this research were to survey and document the current diversity of marine slugs on both the Eastern Shore and the Chesapeake Bay. This was accomplished through methods of collection such as snorkeling and wading followed by laboratory examination of collected specimens. Of the seven sites sampled (5 Atlantic and 2 Bay sites) two species in two families were collected during an eight week period from June – July, 2005. Both species were collected from the Eastern Shore and are new records for that area. Additional sampling is necessary to fully assess current diversity levels.

EXPERIMENTAL EFFECTS OF FOREST REGENERATION METHODS ON SALAMANDER POPULATIONS UP TO 11-YEARS POST-TREATMENT. Jessica A. Homyack[1], Carola A. Haas[1] & Shannon M. Knapp[1,2]. [1]Dept of Fisheries and Wildlife Sciences, Va. Polytechnic Inst. & State Univ., Blacksburg VA 24061 and [2]Dept. of Statistics, Purdue University, West Lafayette IN 47907. In commercial and public forests, silvicultural systems are expected to maintain ecological sustainability in addition to reaching economic, social, recreational, and aesthetic objectives. Plethodontid salamanders are physiologically tied to microhabitat and microclimatic conditions and may play critical roles in energy and nutrient cycling and thus are model organisms for examining effects of forest management. To investigate effects of forest management on salamanders, a suite of 7 oak regeneration treatments, ranging from no treatment to clearcut harvest, were experimentally applied across 7 replicates in southwestern Virginia and West

Virginia during 1994-1998. Terrestrial salamander populations were monitored pre- and post-treatment with night-time, area-constrained searches from spring-fall 1994 through 2005. We report trends in salamander populations on 4 sites that were sampled nearly every year up to 11-years post-harvest with >4,500 salamanders captured. Plethodontid salamanders were less abundant on plots following all over-story removal treatments as compared to either control or herbicide treated plots ($P<0.05$), and abundances remained below 50% of pre-treatment levels 7-11 years since the initial harvest. Ongoing research will examine effects of repeated-stand entries to salamanders, potential mechanisms for the slow recovery of populations, and the ecological consequences of reduced densities of salamanders.

THE EFFECTS OF HERBIVORY ON A RARE, WETLAND LEGUME, *AESCHYNOMENE VIRGINICA*. C. Eck[1] and A.B. Griffith[2]. [1]Dept. of Environmental Sciences and Geology, University of Mary Washington. [2]Dept. of Biological Sciences, University of Mary Washington, Fredericksburg VA 22401. The Endangered Species Act grant endangered species the right to life regardless of any monetary value they may or may not possess. Apart from their intrinsic value, conserving rare plants helps maintain biodiversity that may aid in the long term viability of ecosystems. *Aeschynomene virginica* is a threatened, freshwater, tidal, wetland plant of the mid-Atlantic region. Little is known about the impact of herbivory on seed production of this plant. In September 2005, we conducted a census of all populations on the Cumberland Marsh Preserve, New Kent County, VA. The mean % of seeds eaten per plant for all populations was 9.4 %. The mean % incidence of herbivory per population was 66%. We found no significant relationships between % of seeds eaten or % incidence of herbivory and number of plants per population, distance to nearest population, or distance to nearest corn field. This year we found no relationships between seed predation and population size, population density, or distance from potential herbivore source. But, population size of *A. virginica* was the lowest since 1998 and random error in the small census could swamp relationships. The mean levels of herbivory suggest a possible important decrease in seed production, especially in low population years. We plan two more years of data collection to develop a broader picture of seed predation impact on this rare plant.

A COMPARATIVE STUDY OF THE HARVESTMEN OF THE FAMILY MANAOSBIIDAE (OPILIONES, LANIATORES) FROM TRINIDAD, W. I. Daniel N. Proud, Virginia Wesleyan College, 1584 Wesleyan Drive, Norfolk VA 23502. Prior studies of the harvestmen (Arachnida, Opiliones) of Trinidad, W. I. have documented the occurrence of 24 species on the island, including 2 species (*Cranellus montgomeryi* and *Rhopalocranaus albilineatus*) of the family Manaosbiidae. Relatively little is known about the distribution or natural history of these harvestmen. From 9 July to 5 August 2005, I collected adult specimens of *C. montgomeryi* and *R. alblineatus* from several locations. From 20 July to 5 August 2005, I hiked and camped along Morne Bleu Ridge and collected adults of a manaosbiid species that had not previously been reported for the island. I collected this species in montane rainforest and elfin woodland only at elevations above 600

m. This past year, I used light microscopy and scanning electron microscopy to examine important diagnostic characters of these harvestmen, including the armature of the pedipalps, legs, chelicerae, eye mound, and dorsum as well as the number of articles on the basitarsus (legs I-IV), the length of the segments of legs I-IV, and total body size (length and width). The results of my study indicate that the previously unreported species of harvestmen is a new species. Efforts are presently underway to complete a preliminary description of this animal and verify its status. (Supported by grants from the Virginia Academy of Sciences Undergraduate Research Fund and the Virginia Wesleyan College Undergraduate Research Fund).

IMPACT, DISTRIBUTION, AND BIOLOGICAL CONTROL OF HEMLOCK WOOLLY ADELGID IN VIRGINIA. T. J. McAvoy, S. M. Salom, A. Lamb & D. Mausel, Dept. of Entomology, Va. Polytechnic Inst. & State Univ., Blacksburg VA 24061. Surveys (90) of hemlock stands (*Tsuga canadensis*) were conducted from 1997 to 2005 from Bath and Rockbridge counties south to Lee and Grayson counties, Virginia and Alleghany, Ash, and Watauga counties North Carolina. Tree health and hemlock woolly adelgid (HWA) (*Adelges tsugae*) infestation rates, a serious pest of hemlock were recorded at each site. Sampling of HWA involved examining the terminal 30 cm of 50 branches at random from at least ten trees at each site. Presence or absence of HWA was noted and the percent of the 50 branches infested with at least one HWA was recorded. Hemlock stand health was determined by measuring: percent crown density, live crown ratio, live branches, live tips, new foliage, and live trees at each site. These six parameters were summed and divided by 6 to obtain a health index. The percentage of sites infested with HWA was 25, 36, 41, 53, 53, 57, 59, 62, and 77 in 1997, 1998, 1999, 2000, 2001, 2002, 2003, 2004, and 2005, respectively. Stand health index declined from 72 to 57 from 1997 to 2005. None of the sites had any tree mortality until 2000 when 8% of the sites had at least one dead tree and in 2005, 30% of the stands had at least one dead tree. Two biological control agents have been released in Virginia, *Sasajiscymnus tsugae* (Coleoptera: Coccinellidae) (8 sites) and *Laricobius nigrinus* Fender (Coleoptera: Derodontidae) (5 sites). *Sasajiscymnus tsugae* has not been recovered however; F_3 *L. nigrinus* has been recovered from most of the release sites. This species appears to be established at these release sites.

REDEFINING VIRGINIA'S PREHISTORIC INDIANS: THE NATIVE AMERICAN COLLECTION FROM THE VIRGINIA DEPARTMENT OF HISTORIC RESOURCES. Donna C. Boyd[1], Cliff Boyd[1], & Richard Guercin[2] [1]Dept. of Soc. and Anth., Radford Univ., Radford VA 24142, and [2]U. S. Forest Service, George Washington and Jefferson Nat. Forest, 5162 Valleypointe Parkway, Roanoke VA 24019. In 2004, the remains of 70 prehistoric (A. D. 300 – 1700) Native Americans from ten sites across the Commonwealth of Virginia were sent by the Virginia Department of Historic Resources (VDHR) to the Radford University Physical Anthropology and Archaeology Laboratory for analysis. Many of these remains, although excavated decades ago, had never been professionally analyzed using current standard osteological techniques. The goals of this study were to record as much as possible about the Native Americans from the VDHR collection

and to bring these collections up to current standards for curation and maintenance. Sixty-two prehistoric Native Americans are identified from the seven Southwest Virginia sites which are the focus of this paper. These include 19 males, 15 females, four adults of indeterminate sex, and 24 subadults. High frequencies of dental pathologies including dental caries, antemortem tooth loss, and enamel hypoplasias are noted across the collection, in addition to multiple evidences for non-specific infection. These observations are consistent with a pattern of declining health associated with an increased dependence on maize agriculture. Our research has also revised and corrected earlier analyses of these individuals and has shown the significance and worth of this collection for further study. We, therefore, strongly recommend continued curation of this collection. This study was funded by a grant from the Va. Dept. of Historic Resources, Richmond.

PLANT DISTRIBUTIONS ALONG CORRIDORS AT THE GRASSY HILL NATURAL AREA, FRANKLIN COUNTY, VA. Gregory D. Turner[1] & Marianne Demko[2], [1]Dept. of Biol., West Chester Univ., West Chester, PA 19383 and [2]Va. Western Comm. Coll., Roanoke, VA 24038. Disturbance from human-made corridors influences plant distributions. Specifically, disturbance influences seed dispersal and microclimate, differentially affecting plant recruitment and survival. To better understand how corridors influence plants, a study was conducted to examine (1) whether plant abundance varies with corridor type and (2) whether plant abundance varies with corridor proximity. The study also assessed environmental factors to help explain distributions. To address these questions, the native grasses *Brachyelytrum erectum*, *Leersia oryzoides* and *Panicum clandestinum*, and the exotic *Microstegeum vimineum,* were quantified adjacent to one of three corridors (paved, gravel, & dirt roads) traversing the Grassy Hill Natural Area. Plants were quantified in transects varying in distance from the corridors. *B. erectum* and *P. clandestinum* were abundant across corridors and at all distances, while *L. oryzoides* and *M. vimineum* were only abundant at corridor edges. Corridor type and proximity were influential as we found significant effects of corridor type on native abundances, while *L. oryzoides* and *M. vimineum* abundance was also affected by proximity. Results suggest that the type of, and proximity to, corridors influences grass distributions, possibly due to microclimatic variation and disturbance itself, and that some species may actually benefit from corridor disturbance.

FECUNDITY OF THE SICKLEFIN REDHORSE, CAROLINA REDHORSE, AND HARELIP SUCKER. M. L. Henebry, R. E. Jenkins & E. Jorgensen-Earp, Dept. of Biol., Roanoke College, Salem VA 24153. The Sicklefin and Carolina redhorses are relatively rare sucker fishes, inhabiting a range hindered by dams. The Harelip Sucker, *Lagochila lacera*, is an extinct species of its monotypic genus, which is closely related to redhorses. Fecundity was studied for Sicklefin and Carolina redhorses and Harelip Sucker to determine reproductive capacity and ovarian cycles. Oocyte counts were taken gravimetrically by 5–6 subsamples of 0.50–2.77 g per Sicklefin and Carolina Redhorse specimen. Sicklefin fecundity ranged 6307–22,298, mean 14,165, in 12 specimens of 385–500 mm SL. Gravid

Sicklefin mean oocyte size ranged 2.58–3.15 g. The Sicklefin's annual pattern of ovarian development includes increase in GSI and oocyte size during March and especially April, the start of spawning and occurrence of some spent fish in mid-April, and onset of recrudescence in July or August. Diameters of 4 artificially fertilized, water-hardened, round eggs were 4.10–4.25 mm, mean 4.15 mm. Unspawned eggs taken from 2 ripe females ranged 3.00–3.40 mm, mean 3.17, 3.18 mm. Carolina Redhorse fecundity was 19,907 and 21,384, mean 20,646 in the 2 specimens imminent to spawn. Gravid Carolina Redhorse had oocyte diameters of 2.15–2.70 mm, mean 2.41 mm. Fecundity of the *L. lacera* specimen was 8926 maturing oocytes and an undetermined, manyfold greater number of apparently non-maturing oocytes. Maturing oocytes ranging 1.35–1.60 mm, mean 1.47 mm and non-maturing oocytes from the same subsamples ranged 0.25–0.45 mm, mean 0.323 mm.

IMPACTS OF TROUT STOCKING ON AQUATIC INVERTEBRATE DIVERSITY AND ABUNDANCE IN STREAMS. Amanda A. Crossett & Patrick W. Crumrine, Department of Natural Sciences, Longwood University, Farmville VA 23909. Non-native species can have significant and long-lasting impacts on native communities. Non-native species that replace top predators have the potential to disrupt food webs through predation and competition. Non-native species of trout are commonly introduced to streams in eastern North America to provide recreational fishing opportunities and function as top predators in these ecosystems. Trout species stocked in Virginia are brown trout (*Salmo trutta*) and rainbow trout, (*Oncorhynchus mykiss*). We sampled the aquatic invertebrate community in riffles from streams in Virginia before and after trout stocking events to better understand how these fishes, impact native aquatic invertebrate communities. Although we did not observe changes in species diversity, there were changes in community structure. The number of aquatic invertebrates in riffles increased after the stocking of trout. Mayflies and caddisflies were significantly more abundant in riffles after trout stocking relative to other orders collected from the riffles. These preliminary results suggest that non-native trout influence aquatic invertebrate communities in streams but their complete impacts remain to be fully described.

Psychology

CLICK IT OR TICKET VS. FLASH-FOR-LIFE: A COMPARISON OF INTERVENTION TECHNIQUES TO INCREASE SAFETY-BELT USE OF STUDENTS AT A LARGE UNIVERSITY. Matthew G. Cox, E. Scott Geller, Christina L. Goodwin, & Steven W. Clarke, Department of Psychology, Va. Polytechnic Inst. & State Univ., Blacksburg, VA 24061. While safety-belt use in the U.S. is high (80%), non-use remains an ongoing issue requiring intervention. The most widely used technique to increase safety-belt use is the national Click it or Ticket (CioT) campaign. Another technique used, while less well known, is the Flash-for-Life (FfL). This intervention employs a person holding a sign asking drivers to buckle up on one side; then on the other side, thanks them when they do

so. This study examined the effectiveness of the respective sign for each intervention to increase belt use in 2 commuter parking lots at a large university. In addition, observations were made on positive/negative hand gestures and positive/negative facial expression made when drivers were exposed to the respective signs. Data were collected during 3 non-consecutive 1 hour shifts, 4 days a week for 2 months. Researchers targeted unbuckled student drivers leaving the parking lots and flashed the respective sign, alternating signs each day. A total of 1,822 student drivers (574 women, 1,248 men) were exposed to the signs. Of those exposed to the FfL sign, 34% buckled, vs. 25% compliance with the CioT sign. In addition, the FfL sign elicited significantly more positive and less negative facial expressions and hand gestures than the CioT sign. Overall, the FfL technique appears to be more effective at increasing safety-belt use among college students who seem to be more receptive to the FfL technique. Further research should examine the lasting effects of the FfL intervention.

BETTER MEDICATION ORDERING THROUGH TECHNOLOGY: EVALUATING BEHAVIORAL RESULTS OF A SHIFT TO ELECTRONIC MEDICATION ORDERING. Patrick A. Rhodes, David M. Harris, Thomas R. Cunningham, & Christina L. Goodwin. Virginia Polytechnic Institute and State University, Blacksburg, VA 24061. Nineteen percent of medications in U.S. hospitals are administered in error. Computerized Physician Order Entry (CPOE) potentially decreases these errors by eliminating problems with current handwritten systems. This data-based paper will present objective observations obtained at two regional hospitals. The research investigated the impact of a CPOE system on several physician medication ordering behaviors. Many people are injured each year as a result of adverse drug events, and CPOE is considered critical to reducing this number. The dependent measures are order compliance, time-to-first-dose of antibiotic, and reported medication incidents. Data were obtained by reviewing over 1,000 medication orders over four months. Data compare compliance and efficiency measures pre- and post-CPOE implementation, as well as between- and within-group comparisons of written and CPOE orders. Measures of reported medication incidents from the intervention hospital were compared to the control hospital. Greater rates of compliance and efficiency for electronic orders were found. Implications for future CPOE system implementation and patient safety will be discussed.

IMPROVING MEMORY IN THE ELDERLY VIA POSITIVE FEEDBACK. Kathryn Van Veen & David G. Elmes, Dept. of Psychology, Washington and Lee Univ., Lexington, VA 24450. Elderly people frequently complain about having difficulty remembering names. We report on two experiments testing the effect of feedback on learning and retention of names and occupations. College students and elderly participants had to remember the names and occupations of faces seen on a computer. After matching on first trial performance, half the participants received feedback informing them that they had done very well. The remaining participants received no feedback. On subsequent trials after feedback, the elderly who received feedback recognized names, but not occupations, better than the elderly who did not

receive feedback. Feedback did not influence the college students' recognition. Both experiments showed the same pattern of results. One way to interpret the results is to consider the name memory task as a stereotype threat to the elderly. Feedback lifts the stereotype threat, and the elderly recognize names better on subsequent trials. Recognition of occupations is not a stereotype threat to the elderly, so feedback did not influence recognition of occupations. Since stereotype threat was irrelevant to the college students, feedback and stereotype lift did not occur for the students. Removing stereotype threat might be an effective addition to memory remediation programs for the elderly.

THE EFFECT OF PFIESTERIA TOXIN ON LEARNING IN RATS: REPEATED ADMINISTRATION AND PERFORMANCE IN THE RADIAL-ARM MAZE. Shawn L. Dickerson, Perry M. Duncan, & Rebecca G. McBride, Dept of Psychology, Old Dominion Univ., Norfolk, VA 23508. *Pfiesteria piscicida* is a toxic dinoflagellate with lethal effects on fish and cognitive effects on humans. The cognitive effects consist of impairment for memory and learning which has been previously demonstrated in rat models. This experiment utilized twenty-three male Long-Evans rats, twelve of which were injected intraperitonealy with a *Pfiesteria* culture and eleven which were injected with a non-toxic water culture. This study used repeated administration of the *Pfiesteria* toxin for three weeks to be more similar to human exposure. The rat subjects were tested with a radial-arm maze (RAM) twice each week, where three of the eight arms were baited. The researcher recorded total errors for each rat over each week. Results indicate minimal support for the hypothesis that the experimental group would progressively get worse at learning the RAM over several weeks after repeated exposure to *Pfiesteria*. The results were not found to be significant but the mean total errors did suggest an emerging difference between the two groups. Additional research is required to demonstrate clearly that *Pfiesteria* toxin interferes with learning upon repeated exposure.

THE EFFECT OF PFIESTERIA TOXIN AND ETHANOL ON RAT SPONTANEOUS MOTOR ACTIVITY AND PERFORMANCE IN THE ELEVATED-PLUS MAZE. Jammie M. Abbott, Department of Psychology, Old Dominion University, Norfolk, VA 23529. *Pfiesteria piscicida* is an ambush predator dinoflagellate that has been implicated in multiple health problems. To fully understand and mitigate the impact of *Pfiesteria* this research attempts to determine if *Pfiesteria* exposed rats have significantly different spontaneous motor activities and anxiety-related behaviors than non-exposed rats. In order to evaluate these previously documented behaviors fully two interwoven experiments were conducted. In the first experiment a total of 32 rats were randomly separated into either a control or an experimental group. In this part of the experiment the anxiety level of the *Pfiesteria* exposed group and control group participants were evaluated utilizing an Elevated-Plus Maze (EPM). Anxiety for this experiment was operationally defined as greater time spent in the closed arms of the EPM. Data obtained from this portion of the experiment and its subsequent analysis with mixed ANOVAs indicated that participants in the *Pfiesteria* exposed group were

significantly more anxious than participants in the control group. One day after initial experimentation was completed, Spontaneous Motor Activity (SMA) was evaluated in the same participant groups utilizing three different doses of ethanol. In this part of the experiment participants' motor activities as denoted by ambulation and rearing were detected and recorded by IR light-sources, photocells, and computer systems. Data obtained from this portion of the experiment was inconclusive producing similar ethanol effects on Spontaneous Motor Activity for both the *Pfiesteria* exposed and control groups.

AN INVESTIGATION OF CONTROL CONDITIONS IN ASCH-TYPE EXPERIMENTS: VII.   Joshua M. Taylor, Alexander R. Titus, Zachary A. Philbrick, E. JoAnn Boyce, Ahmad J. Bah, Rodolfo E. McIntyre, & James P. O'Brien, Tidewater Cmty. Coll., Virginia Beach, VA 23453. For almost 60 years replications of Solomon E. Asch's classic group pressure paradigm have typically failed to conduct adequate control groups. This neglect reflects a prevalent assumption that high stimulus clarity, an essential feature of the "Asch dilemma," obtains for all participants in all experimental treatments. However, this 2x2x2x2 control replication (N=689) confirms that Experimenter-Participant contextual factors interact complexly to produce stimulus ambiguity among female participants and most men. This factorial design systematically manipulated Experimenter gender and status (authoritative vs. peer) and participant gender and institution of origin (4-yr. vs. community college). All Es and male participants were White (as in Asch) but, since there is little stimulus clarity data for women, female participants were not restricted on ethnicity. Of the 16 conditions, only the direct replication of Asch's controls – 4-yr. White male undergraduates with an Authoritative White male Experimenter (n=37) – closely approximated Asch's standards for stimulus clarity. Since the baselines of other participants emanate from stimulus ambiguity, the vast literature (including Asch's group pressure treatments with female Experimenters) must be reevaluated regarding issues such as the persistent sex difference, internal validity, population validity, cultural relativism, the nature of the cognitive conflict, and corruption by informational influence (in addition to normative social influence). Abstracts of previous interim reports appear in the *Proceedings* issues of *Va. J. Sci.* 1999-2005.

ETHNICITY IN ASCH CONTROL REPLICATIONS: AFRICAN-AMERICAN PEER EXPERIMENTERS AND COMMUNITY COLLEGE PARTICIPANTS: II. James P. O'Brien, E. JoAnn Boyce, Alexander R. Titus, Joshua M. Taylor, Zachary A. Philbrick, Ahmad J. Bah, Rodolfo E. McIntyre, Sulaiman T. Bah, Neysa L. Isler, Natalie A. Clouser, Lauren H. Compton, Tiffany Blake, Gayle P. Lentz, Andrea L. Atwell, Lauren K. Burt, Denise A. Lugenbeal, Elisa M. Ramirez-Feliciano, Danial J. Kim, Adam J. Stinson, Elizabeth S. Martin & Sakeenah T. Abdullah, Tidewater Cmty. Coll., Virginia Beach, VA 23453. Danso and Esses (2001) found evidence for stereotype threat activation among White participants on a test of mathematical reasoning; participants high in social dominance orientation performed significantly better when the test administrator was Black rather than White. Since the Asch stimuli are relatively neutral, would E's ethnicity affect stimulus clarity measures?

The procedure is identical to that described above (Taylor, et al), with two exceptions: (1) E (male or female) is of African-American descent and (2) groups were mixed genders and ethnicities. Comparing the stimulus clarity measures for these White male Ss with Black male Es (n=78) or with Black female Es (n=26) with similar cells in the main protocol (White male or White female peer Es), there is no evidence of stereotype threat activation. For White female participants and Black male Es (n=59), the hypothesis of stereotype threat activation is supported. Since 79% of Danso and Esses' Ss were women, sex x ethnicity interactions are suggested. Many sample sizes are still too small for analysis and data using Black authoritative Es (instead of peers) have not yet been acquired. An abstract of the first interim report of this protocol (Bah, et al.) appeared in *Va. J. Sci.*, 54 (2), Summer 2003, p. 108.

THE EFFECTIVENESS OF AUDITORY COLLISION AVOIDANCE WARNINGS IN REDUCING FATIGUE-RELATED CRASHES. Jennifer F. May[1], Carryl L. Baldwin[1], & Raja Parasuraman[2]. [1]Old Dominion University, Department of Psychology, [2]George Mason University, Department of Psychology. The goal of this study was to examine the effectiveness of two auditory collision avoidance system (CAS) warnings for reducing crash rates in fatigued drivers faced with a potential rear-end collision. Forty-five participants between the ages of 18 to 82 ($M = 46.56$, $SD = 22.52$), including 19 between the ages of 18-35 and 23 between the ages of 60-82, were included in the analysis. Participants completed a 1.5 hour fatigue inducement process followed by a potential collision scenario. Fatigue was determined from the continuous measure of lane position variability (LPV), and was calculated at 1 standard deviation above the participant's baseline LPV. Once the LPV reached 1 SD above baseline during the collision scenario, an event was triggered where the lead car suddenly and rapidly decelerated to a stop. Participants either heard a verbal warning "danger," a 1000 Hz tone or no warning. A binary logistic step forward regression indicated that CAS warning type was the only predictor of CAS response, $\beta = -.975$, $p = 0.037$, Nagelkerke $R^2 = .151$. Eight of the 13 crashes occurred in the no warning condition. The presence of a CAS warning was particularly beneficial to reducing crashes in older drivers, $\beta = -2.207$, $p = 0.05$, Nagelkerke $R^2 = .392$. Following distance was significantly greater in the older group, $F(1, 36) = 13.57$, $p = .001$, $\eta^2 = .25$. Stopping distance was also greater for older drivers, $F(1, 23) = 6.6$, $p = .017$, $\eta^2 = .22$. Results of this study indicate that auditory CAS warnings may help reduce fatigue-related rear-end crashes, particularly among older drivers.

JUGGLING MULTIPLE ROLES WHILE MAXIMIZING LIFE SATISFACTION. Marian L. Troutman & Barbara A. Winstead, Department of Psychology, Old Dominion University, Norfolk, VA 23529. The present study examined the demands of multiple roles and the coping strategies that individuals use to maximize their work, parenting, and general life satisfaction. Participants included 31 college students who were both workers and parents. They completed questionnaires that assessed family and work demands, coping strategies, conflict, spillover, and parent, work, and life satisfaction. The researcher hypothesized that for participants who

face multiple demanding roles, the use of coping strategies and positive spillover would positively correlate with levels of parent, work, and life satisfaction. Also, levels of conflict would negatively correlate with levels of parenting, work, and life satisfaction. Pearson's r was used to test hypotheses. Partially supporting one of the three hypotheses, researchers found work-family conflict to be negatively related to work satisfaction. Using a larger and more representative sample, future research should examine job and family involvement to see how levels of role demands moderate the relationships such that correlations will be stronger when role demands are higher.

THE EFFECTS OF RELATIVE SYSTEM RELIABILITY AND PRIORITIZATION ON ALARM REACTION TIME. Elizabeth T. Newlin, Ernesto A. Bustamante, James P. Bliss, Randall D. Spain, & Corey K. Fallon, Department of Psychology, Old Dominion University, Norfolk, VA 23529. Alarm system operators often manage multiple alarm systems concurrently. Because such situations frequently accompany cascading events, it is important to know how operators sequence responses. We examined how relative reliability and priority of two concurrent alarms affected alarm reset patterns and response times. We hypothesized that operators would respond first to an alarm with higher reliability or higher priority when the other variable was held constant. We expected that participants would respond to alarms with higher priority and that response times would increase when one alarm was more reliable and the other alarm had higher priority. Sixty-one Old Dominion University undergraduates performed a tracking task and responded to concurrent alarms. A between-subjects ANOVA revealed that participants responded to alarms with higher priority first when reliability was constant and to higher reliability alarms first when priority was constant. Participants did not respond significantly more often to the higher priority alarm when one alarm was more reliable and the other alarm had higher priority. A mixed ANOVA demonstrated there was no difference in response times across conditions. Our results suggest that relative priority and reliability may be useful parameters to control in complex task sequencing.

DETERMINANTS OF BODY IMAGE ATTITUDES AND EATING DISTURBANCES IN BLACK COLLEGE WOMEN. Sharnail D. Bazemore & Thomas F. Cash, Department of Psychology, Old Dominion University, Norfolk, VA 23529. The present study examined the effect of family and peer groups, ethnic identity, and media images on body image ideals and eating disturbances among Black women. Participants included 186 Black female psychology students from Old Dominion University. The current study merged an existing dataset of 115 participants with data collected from an additional 69 participants to attain desired sample size. Participants completed a series of online questionnaires that evaluated self-attitudes related to body image, eating habits, past and present social groups, ethnic identity, and personal experiences with racial diversity. Pearson correlations revealed all variables, with the exception of family and peer groups, had a significant impact on the formation of body image and eating attitudes in Black women. Past peer groups were moderately related to body image and eating

attitudes. Standard multiple regression analyses revealed Black Media Internalization was the only significant predictor of Self-Evaluative Salience, and Self-Hatred and Anti-White were the only significant predictors for Eating Attitudes. Our study also confirms that additional research is needed to identify variables within the Black culture that are pertinent to the development and prevention of eating disturbance and negative body image. This is particularly relevant to clinical populations. Limitations and implications for future research are discussed.

Statistics

GENE NETWORK INFERENCE VIA GENETIC ANALYSIS OF EXPRESSION PROFILES IN SEGREGATING POPULATIONS. Bing Liu[1], Alberto De la Fuente[2] & Ina Hoeschele[1], [1]Dept. of Stat. and Va Bioinformatics Institute, [2]Va Bioinformatics Institute, Va. Polytechnic Inst. & State Univ., Blacksburg, VA 24061. Genetical genomics experiments are multifactorial perturbation experiments in which a segregating population is expression profiled for ten thousands of genes and DNA marker genotyped for hundreds or thousands of markers. Quantitative Trait Locus (QTL) mapping identifies which genomic regions influence the expression of which genes, and which genes have causal, regulatory effects on other genes. This information is used to construct a causal, encompassing network of regulatory relationships among genes and QTL. Subsequently, the network is sparsified using Structural Equation Modeling (SEM), which retains only direct regulatory relationships. As opposed to current Bayesian network analyses, SEM analysis does not require discretization and is able to model networks with cycles or feedback loops. QTL mapping is performed by genome-wide and localized searches of individual expression profiles and principal components. For each QTL region, we obtain a list of genes whose expression is affected and a list of genes physically located in the region (candidate regulators). The candidate regulator list is reduced using local structural models and additional biological information. SEM analysis is being implemented in Maximum Likelihood and Bayesian frameworks. The SEM contains expression profiles, QTL and certain types of interactions. Typically, these models have been implemented for tens of variables. Here we aim for applications involving at least hundreds of variables based on a factorization of the likelihood and a strongly constrained network topology space.

MODEL-BASED CLUSTERING IN A BROOK TROUT CLASSIFICATION STUDY WITHIN THE EASTERN UNITED STATES. Huizi Zhang, Samantha Bates Prins & Eric P. Smith, Dept. of Stat., Va. Polytechnic Inst. & State Univ., Blacksburg, VA 24061. When dealing with data compiled over a large spatial region, a single model may not be appropriate to describe relationships between variables. We developed a model-based clustering method to group categorical response data by their empirical stressor-response relationships with the goal of better classification performance after clustering. Voronoi tessellations techniques are implemented to subdivide a region and the area under the receiver operator

characteristic curve is used as the criterion when searching for the optimal clustering. This method is applied to a carefully brook trout absence/presence data within the eastern United States. Results indicate fairly strong stressor-response relationships that vary spatially and show significant improvement over the conventional single model approach.

RANGES OF MEASURES OF ASSOCIATIONS FOR FAMILIAL BINARY VARIABLES. N. Rao Chaganty & Yihao Deng, Department of Mathematics and Statistics, Old Dominion University, Norfolk, VA 23529. Familial binary data occur in a wide range of scientific investigations. Numerous measures of association have been proposed in the literature for the study of intra-family dependence of the binary variables. These measures include correlations, odd ratios, kappa statistics, and relative risks. In this talk, we will study the permissible ranges of these measures of association such that a joint distribution exists for the familial binary variables.

DOES PAIR-MATCHING ON BASELINE MEASURES IMPROVE POWER IN A PRE-POST CLUSTER RANDOMIZED TRIAL? Misook Park & Robert E. Johnson, Dept. of Biostatistics, Va Commonwealth U., Richmond, VA, 23298. The variance between cluster units may be controlled in part by matching prior to randomization. Clusters may be placed into blocks by matching on known characteristics such as demographics, cluster size, etc. The baseline measure of the study primary outcome is oft recommended for matching. One matching scheme is to first sort clusters on their baseline means and match the two clusters with the smallest means into a block, match the two clusters with the next smallest means, etc. Does this matching strategy decrease the variance and improve the power to detect treatment effects? Standard methods involve using the baseline mean as a covariable or analyzing pre-post differences. Does the addition of matching improve these methods? We investigate this question in light of the variance components, ICC, pre-post correlation, and allocation of within-cluster sample size across time points.

GENETIC CONSTRAINED K-MEANS ALGORITHM. Jianmin Zhao & Robert E. Johnson, Department of Biostatistics, Virginia Commonwealth University, Richmond, VA 23298. Inspired by Krishna and Murty Genetic K-means Algorithm (GKA), we propose a novel Genetic Constrained K-means Algorithm (GCKA). In our work, each cluster is constrained to contain at least two subjects. The Constrained K-means Operator (CKO), rather than K-means Operator, is used in GCKA. A solution that violates the constraint constitutes an illegal string which must be accounted for in GKA. The constrained K-means algorithm generates the initial population; hence we do not need to consider the illegal string issue in this stage. CKO greatly speeds up the convergence process. CKO first performs the standard K-means algorithm, then relocates the subjects so that there are at least two subjects in each cluster. Lastly subjects are relocated in order to reduce the total objective value while satisfying the constraint. The objective function used in this paper is Root Mean Squared Error (RMSE). Based on simulated and experimental

data, we demonstrated that GCKA be able to detect the orrect clusters when clusters exists. We also showed that GCKA always converge to global optimum, though the convergence may be slow.

AN IMPROVED GENETIC ALGORITHM WITH THE METHOD OF STEEPEST ASCENT/DESCENT. Wen Wan, Jeffrey B. Birch & G. Geoffrey Vining, Dept. of Stat., Va. Polytechnic Inst. & State Univ., Blacksburg VA 24061. The genetic algorithm (GA) is an important tool in optimization area. However, the general GA is usually computationally intensive. It has to perform a large number of evaluations of an objective function. This paper presents a computationally efficient genetic algorithm by applying the method of steepest ascent/descent from the response surface methodology to improve the general GA. During the process of a GA, on the whole, successive generations tend to find improvement in terms of the values of an objective function. Our modified GA utilizes numerical information from the GA process itself to try to obtain further possible improvement. The modified GA focuses on the best offspring among the current population and its offspring population. Similar to the method of steepest ascent/descent, the modified GA finds three appropriate directions so that further improvement may be found by ollecting data directly and economically along those appropriate paths until no further improvemen can be found. Then by replacing the best offspring by the best point found, the GA process is continued until the next best offspring better than the current population is found. The proposed method can greatly improve the performance of the general GA. Several examples, such as low-dimensional versus high-dimensional cases, and smooth response surface versus bumpy response surface cases, are employed to illustrate the improvement of the proposed method. This paper also explores varying the GA by considering several different levels of various GA operators through a Monte Carlo simulation study using a split-plot design.

SAMPLING RARE AND ELUSIVE SPECIES: THE SEPARATION OF COMPONENTS OF DETECTION PROBABILITY IN WILDLIFE AND FISHERIES POPULATION ESTIMATION. Kenneth H. Pollock, Departments of Zoology and Statistics, North Carolina State University, Raleigh, NC 27695-7617. Population abundance estimation for rare and elusive species critically depends on the estimation of detection probability under a particular sampling method. I discuss in detail two components of detection probability. These are the probability of an animal being available for detection and the conditional probability of an animal being detected given that it is available. Methodology for estimating these two components of detection probability is illustrated with three very diverse examples involving aerial surveys of marine mammals (dugongs), point counts of terrestrial birds, and capture-recapture studies of terrestrial salamanders. The statistical methodology used in the three examples is very different. If we ignore the issue of animals not being available, then we obtain an estimate of the size of the available component of the population rather than the total population size. The available component may be only a small proportion of the total population. In addition, this component may vary with time and with important auxiliary variables in ways that

are so complex that it is unsatisfactory for monitoring the population. I will conclude my talk with some general remarks on the challenges of interdisciplinary research, the future of statistics as a field and the training of quantitative students who work at the interface of Statistics, Biomathematics and Wildlife Ecology.

AN ASYMPTOTIC VIEWPOINT ON HIGH-DIMENSIONAL BAYESIAN TESTING. Dan Spitzner, Dept. of Stat., Va. Polytechnic Inst. & State Univ., Blacksburg, VA 24061. Bayesian testing is studied asymptotically on a high-dimensional normal means model, in which the null hypothesis of zero means in all dimensions is tested against general alternatives. This is known to serve as a canonical model for smooth goodness-of-fit testing. The asymptotic setup is such that prior mass placed on the null hypothesis is allowed to decrease as dimensionality increases, while at the same time the dispersion of the prior placed on the alternative is allowed to increase, thereby tending toward a noninformative specification. When geometric constraints representing smoothness are imposed it becomes sensible to weight the prior, for which high-dimensional asymptotic evaluation provides a simple weight specification that leads to favorable properties.

MULTIVARIATE ASSAYS WITH VALUES BELOW THE LOWER LIMIT OF QUANTITATION: PARAMETRIC ESTIMATION BY IMPUTATION AND MAXIMUM LIKELIHOOD. Robert E. Johnson, Dept. of Biostat., Va Commonwealth U, Richmond, VA, 23298 & Heather J. Hoffman, Biostatistics Center, George Washington University. Laboratory assay data often include left-censored values that are reported to be below the lower limit of quantitation (BLLOQ or $\leq$ LOQ). While simple imputation of a specific value such as LOQ/2 is commonly implemented in practice, maximum likelihood methods accounting for censoring provide a more accurate way of analyzing the data. Assay measures such as biomarker levels or concentration levels of contaminants in water are typically modeled with a normal or lognormal distribution. The corresponding maximum likelihood estimate of means and variances in univariate analyses can easily be obtained from an assortment of standard software packages; however, a multivariate analysis may be more appropriate when multiple assays are measured on the same subject. For example, total nicotine intake may be represented by a linear combination of the amount of nicotine and its five metabolites present in some physiological fluid. Especially in unexposed nonsmokers, one or more of these measures may fall below the LOQ. In this case the total nicotine cannot be directly measured. Simple imputations will suffice when the proportion of data BLLOQ is small. When this is not the case, we propose an algorithm that provides maximum likelihood estimates of mean and unstructured (co)variance parameters corresponding to a multivariate (log)normal distribution in the presence of left-censored and missing values. This work is based in part on Heather J. Hoffman PhD dissertation.

OBJECTIVE PRIORS FOR THE MULTIVARIATE NORMAL MODEL. <u>Dongchu</u> <u>Sun</u>, Va. Polytechnic Inst. & State Univ., Blacksburg, VA 24061 & James O. Berger, Duke University, Durham, NC 27708. Objective Bayesian inference for the multivariate normal model is illustrated, using different types of objective priors (Jeffreys, invariant, reference and matching), different modes of inference (Bayesian and frequentist), and different criteria involved in selecting optimal objective priors (ease of computation, frequentist performance, marginalization paradoxes, and decision-theoretic evaluation). A variety of surprising results were found, including the availability of objective priors that yield exact frequentist inferences for many functions of the parameters, such as the correlation coefficient. The prior that most frequently yields exact frequentist inference is the right-Haar prior, which unfortunately is not unique. Two natural proposals are studied for dealing with this non-uniqueness: first, mixing over the right-Haar priors; second, choosing the mpirical Bayes right-Haar prior, that which maximizes the marginal likelihood of the data. Quite surprisingly, we show that neither of these possibilities yields a good solution. This is disturbing and sobering. It is yet another indication that improper priors do not behave as do proper priors, and that it can be dangerous to apply nderstandings from the world of proper priors to the world of improper priors.

VIRGINIA JUNIORACADEMY OF SCIENCE
2006 AWARDS

AGRICULTURE AND ANIMAL SCIENCE

Honorable Mention: JENNA M. BOYER
Southwest Virginia Governor's School

Honorable Mention: CORTNEY Y. NEWELL AND DANIELLE K. PETERS
Mills E. Godwin High School

Honorable Mention: AMANDA L. THOMAS
Prince Edward County High School

Third Place: CLAYTON M. GEIPEL
George H. Moody Middle School

Second Place: JESSIE C. CAPPELLO
Stonewall Jackson Middle School

First Place: JACQUELINE R. ADDESA
Central Virginia Governor's School

ANIMAL BEHAVIOR (ETHOLOGY)

Honorable Mention: NIKOLAS W. HAYES
Henrico High School

Honorable Mention: STEPHEN B. TAYLOR
Maggie L. Walker Governor's School

Third Place: CAMERON   COVINGTON,   WILLIAM   HENLEY AND
BAILEY GAFFNEY
Goochland High School

Second Place: BRITTANY M. MCLANE
Mills E. Godwin High School

First Place: GRACE Z. WANG
Mills E. Godwin High School

BOTANY A

Honorable Mention: BENJAMIN E. ABRAHAM
Mills E. Godwin High School

Honorable Mention: EMILY L. BARNETT
George H. Moody Middle School

Honorable Mention: RYAN L. FAUBER
George H. Moody Middle School

Third Place: SAMANTHA A. HOELZER
Roanoke Valley Governor's School

Second Place: KATHERINE L. HAPGOOD
Roanoke Valley Governor's School

First Place: AMANDA E. DERRINGER
Roanoke Valley Governor's School

BOTANY B

Honorable Mention: JORDAN A. MANDEL
Thomas Jefferson Middle School

Honorable Mention: AMY L. TOGNA
Hermitage High School

Third Place: ADRIANA M. PHILLIPS
Williamsburg Middle School

Second Place: MARIA P. PAWLOSKY
Bishop Denis J. O'Connell High School

First Place: LAURA K. LONG
Roanoke Valley Governor's School

CHEMISTRY A

Honorable Mention: JOHN F. CARROLL
Central Virginia Governor's School

Honorable Mention: MAXWELL W. DUNCAN
Yorktown High School

Honorable Mention: CONSTANCE D. FRANKLIN
Central Virginia Governor's School

Third Place: YASSER J. EL-ABD
Central Virginia Governor's School

Second Place: DAVID T. FISHER
Maggie L. Walker Governor's School

First Place: KATHLEEN E. FLEMING
Yorktown High School

CHEMISTRY B

Honorable Mention: ANDREW D. SAMORA
Yorktown High School

Third Place: ALEXANDRA L. VULCANOFF
George H. Moody Middle School

Second Place: AMY L. ORR
Central Virginia Governor's School

First Place: BENJAMIN M. SPENCE
Mills E. Godwin High School

COMPUTER SCIENCE

Honorable Mention: JASON T. BAUMGARTNER
Deep Run High School

Third Place: GASTON W. DIETZ
Shenandoah Valley Governor's School

Second Place: STEVEN B. COPELAND
Deep Run High School

First Place: ERIC J. WELANDER
Deep Run High School

CONSUMER SCIENCE A

Honorable Mention: FELICIA A. HOLZGREFE
Atlee High School

Third Place: MARTHA A. KAHLSON
Mills E. Godwin High School

Second Place: CLAIR M. KARAFFA
Shenandoah Valley Governor's School

First Place: MICHAEL P. GIUFFRIDA
Maggie L. Walker Governor's School

CONSUMER SCIENCE B

Honorable Mention: KATHRYN L. MCLANE
George H. Moody Middle School

Honorable Mention: KATHRYN M. PORTER
Hermitage High School

Honorable Mention: MOLLY B. SHEA
Shenandoah Valley Governor's School

Third Place: DANIEL D. STRAUS
Yorktown High School

Second Place: MAREN T. VAN HUSS
Shenandoah Valley Governor's School

First Place: ERIKA E. POWELL
Douglas Freeman High School

EARTH AND SPACE SCIENCE

Honorable Mention: CAITLIN M. ALEXANDER
Shenandoah Valley Governor's School

Honorable Mention: KRISTIN R. FIELDS
Southwest Virginia Governor's School

Honorable Mention: JOSEPH F. WOOD
James River High School

Third Place: APURVA PANDE
George H. Moody Middle School

Second Place: ELI J. GORSKI
                    Mills E. Godwin High School

First Place: ADARSH R. RAMAKRISHNAN
                    Mills E. Godwin High School

ENGINEERING A

Honorable Mention: APRIL B. BAKER
                    Shenandoah Valley Governor's School

Honorable Mention: BRADLEY F. CRADDOCK
                    Deep Run High School

Honorable Mention: LAUREN E. DEMOSS
                    Shenandoah Valley Governor's School

Third Place: JENNIFER L. DOWNS AND ANNE D. TALLEY
                    Mills E. Godwin High School

Second Place: SEUNGHYUP B. HAN
                    Maggie L. Walker Governor's School

First Place: WILLIAM J. BROWNHILL
                    Deep Run High School

ENGINEERING B

Honorable Mention   CHRISTINE R. JOGERST
                    Central Virginia Governor's School

Honorable Mention: MARINA E. MICHAEL
                    Central Virginia Governor's School

Honorable Mention: TATIANA NICULESCU
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Third Place: ANDREW P. SLOTNICK AND NATHAN O. VAN NATTA
                    Deep Run High School

Second Place: BRYAN J. SHADRON
                    Mills E. Godwin High School

First Place: ANMAR L. SIOCHI
                    Warwick High School

ENVIRONMENTAL SCIENCE A

Honorable Mention: RISHABH BAJEKAL
Mills E. Godwin High School

Honorable Mention: AMRITA BANERJEE
Mills E. Godwin High School

Honorable Mention: CHRISTINA CHOW AND COURTNEY R. CARTER
Chesapeake Bay Governor's School

Third Place: JAMES B. DEEMY
Chesapeake Bay Governor's School

Second Place: NATHANIEL DELANO, JOSHUA FLICKINGER
AND ROBERT RYLAND
Chesapeake Bay Governor's School

First Place: BENJAMIN C. ARANCIBIA
Mills E. Godwin High School

ENVIRONMENTAL SCIENCE B

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Yorktown High School

Honorable Mention: MARY A. GALLAGHER
Yorktown High School

Honorable Mention: NATALIE M. HENDRICK
Hermitage High School

Third Place: JORDAN L. GATES AND LEANNE E. WATROUS
Chesapeake Bay Governor's School

Second Place: AMANDA N. GRANT
Deep Run High School

First Place: ABBY M. HUGHES
Chesapeake Bay Governor's School

ENVIRONMENTAL SCIENCE C

Honorable Mention: HOLLY M. JONES
Chesapeake Bay Governor's School

Honorable Mention: CARA M. NORTON
                      Roanoke Valley Governor's School

Honorable Mention: JOHN B. POTTER
                      Central Virginia Governor's School

Third Place: WILLARD T. OBER
                      Chesapeake Bay Governor's School

Second Place: OMKAR G. KHARKAR
                      Deep Run High School

First Place: ERIN M. KELLUM AND THERESE J. KILLION
                      Chesapeake Bay Governor's School

ENVIRONMENTAL SCIENCE D

Honorable Mention: EDWARD S. RICE AND KAREEM M. EL-GOHARY
                      Thomas Jefferson High School for Science and Technology

Honorable Mention: CATHERINE M. SEALS
                      Central Virginia Governor's School

Honorable Mention: JESSICA S. WANG
                      Mills E. Godwin High School

Third Place: CAROLINE J. TERRY AND ERIKA R. DAHLEM
                      Chesapeake Bay Governor's School

Second Place: MEGAN T. WIND AND TIFFANY J. LEE
                      Chesapeake Bay Governor's School

First Place: JASON D. SHIELDS
                      New Horizons Governor's School

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                      Deep Run High School

Honorable Mention: JOHN N. ADAMS
                      Central Virginia Governor's School

Honorable Mention: JASMINE N. JONTE
Mills E. Godwin High School

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Maggie L. Walker Governor's School

Second Place: JAKE M. SATIN
Douglas Freeman High School

First Place: SOHINI SIRCAR
Maggie L. Walker Governor's School

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Maggie L. Walker Governor's School

Honorable Mention: CHRISTOPHER P. RA
Roanoke Valley Governor's School

Third Place: PRAKRITI VERMA
Grafton High School

Second Place: FERNANDO D. DE FARIA
Shenandoah Valley Governor's School

First Place: ZECHARIAH T. ZIMMERMAN
Roanoke Valley Governor's School

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Mills E. Godwin High School

Honorable Mention: NIYANT A. JAIN
Mills E. Godwin High School

Third Place: STEPHEN L. JOYCE
Goochland High School

Second Place: SARAH L. COLEMAN
Shenandoah Valley Governor's School

First Place: DAVID J. HANNA
                      Mills E. Godwin High School

MEDICINE AND HEALTH B

Honorable Mention: JESSICA W. LAU
                      George H. Moody Middle School

Honorable Mention: BENJAMIN G. LUKE
                      Wakefield Country Day School

Honorable Mention: EILEEN A. SETIEN
                      James River High School

Third Place: ABIGAIL E. NUNN
                      Deep Run High School

Second Place: AMANDA C. LOTTS
                      Shenandoah Valley Governor's School

First Place: GRETE C. KARUSO
                      Washington-Lee High School

MEDICINE AND HEALTH C

Honorable Mention: LAUREL B. SLOUGH AND CARY P. SPIERS
                      Mills E. Godwin High School

Honorable Mention: RACHEL E. WHEELER
                      Mills E. Godwin High School

Honorable Mention: CHAO YIN
                      Yorktown High School

Third Place: BRITTANY M. SWANN
                      Shenandoah Valley Governor's School

Second Place: JING YUAN
                      Mills E. Godwin High School

First Place: ALISON S. WALTER
                      Maggie L. Walker Governor's School

MICROBIOLOGY A

Honorable Mention: MARIA E. CAMBONE
Bishop Denis J. O'Connell High School

Honorable Mention: THOMAS J.C. MORIE
Yorktown High School

Honorable Mention: PADMA V. CHITNAVIS
Roanoke Valley Governor's School

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Second Place: JUSTINE V. ARRINGTON
Central Virginia Governor's School

First Place: TIMOTHY J. HENDERSON
Central Virginia Governor's School

MICROBIOLOGY B

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Central Virginia Governor's School

Honorable Mention: FALAK F. QADIR
Atlee High School

Honorable Mention: CHRISTA N. WOOD
Hermitage High School

Third Place: DYLAN M. NORVELL
Henrico High School

Second Place: SURAJ K. MISHRA
Mills E. Godwin High School

First Place: MICHAEL A. WONG
Maggie L. Walker Governor's School

PHYSICAL SCIENCE A

Honorable Mention: CLAIRE A. BOBST
Swanson Middle School

Third Place: ALEX B. JONES AND MADISON E. LANE
Swanson Middle School

Second Place: BRANDEN T. KATONA
George H. Moody Middle School

First Place: MEREDITH F. BEARDEN
George H. Moody Middle School

PHYSICAL SCIENCE B

Honorable Mention: CHRISTOPHER D. KIME
Swanson Middle School

Honorable Mention: MATTHEW P. NEWMAN
Swanson Middle School

Honorable Mention: MATTHEW H. NGUYEN
George H. Moody Middle School

Third Place: DANIEL P. REYNOLDS
George H. Moody Middle School

Second Place: HANNAH E. RUMSEY
Gildersleeve Middle School

First Place: CARA M. NEWLON
Williamsburg Middle School

PHYSICS A

Honorable Mention: JOSEPH W. ELDREDGE
Shenandoah Valley Governor's School

Honorable Mention: JENNIFER T. GIUFFRIDA
Deep Run High School

Honorable Mention: AMEYA JAMMI
Mills E. Godwin High School

Third Place: TRAVIS M. GEARY
Shenandoah Valley Governor's School

Second Place: BENJAMIN C. CHARLTON
                     Central Virginia Governor's School

First Place: DAVID K. EDER AND MERCER V. BASYE II
                     Chesapeake Bay Governor's School

PHYSICS B

Honorable Mention: MATTHEW R. MAPLES
                     Gildersleeve Middle School

Honorable Mention: HAYDEN C. TOWNSEND
                     Hermitage High School

Third Place: DEVON M. MILLER
                     Douglas Freeman High School

Second Place: RODRIGO SARLO
                     Central Virginia Governor's School

First Place: ANANT SHULKA
                     Maggie L. Walker Governor's School

PSYCHOLOGY - GENERAL

Honorable Mention: EMILY A. MARTIN
                     George H. Moody Middle School

Honorable Mention: BLAIR J. ROBERTSON
                     Shenandoah Valley Governor's School

Honorable Mention: CHRISTINE A. TRAN
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Third Place: AUDREY G. TRUSSELL
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                     Shenandoah Valley Governor's School

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                     Yorktown High School

PSYCHOLOGY - LEARNING & PERCEPTION A

Honorable Mention: JULIA C. CALLAHAN
                       Deep Run High School

Honorable Mention: AMBER A. DING
                       J.R. Tucker High School

Honorable Mention: CLARENCE T. HUYNH AND EVAN R. CANTOR
                       Deep Run High School

Third Place: EUNICE J. CHUNG
                       Central Virginia Governor's School

Second Place: SARAH E. DANAHER
                       Central Virginia Governor's School

First Place: LEE H. ELLIOTT
                       Central Virginia Governor's School

PSYCHOLOGY - LEARNING & PERCEPTION B

Honorable Mention: PRATIK A. PATEL
                       Central Virginia Governor's School

Third Place: SARAH E. MCDONALD
                       Central Virginia Governor's School

Second Place: CAMILLE M. STITT
                       Central Virginia Governor's School

First Place: DAVID G. WISE
                       Mills E. Godwin High School

PSYCHOLOGY - SOCIAL

Honorable Mention: ELIZABETH N. BRANDT
                       Shenandoah Valley Governor's School

Honorable Mention: NORMA M. CHAMMA
                       Yorktown High School

Honorable Mention: LINDSEY N. URQUIA AND EVA C. ROFFIS
                     Deep Run High School

Third Place: COLLIN P. FITZSIMMONS
                     Deep Run High School

Second Place: MARK R. EDELSTEIN
                     Douglas Freeman High School

First Place: ANNE K. MINOFF
                     Yorktown High School

STATISTICS

Honorable Mention: MANI D. KAMINENNI
                     Mills E. Godwin High School

Third Place: ROHIT BANERJEE AND RAHUL MENON
                     Mills E. Godwin High School

Second Place: MATTHEW J. BROWN
                     Mathematics and Science High School at Clover Hill

First Place: ROHIT BANERJEE
                     Mills E. Godwin High School

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Honorable Mention: AARON A. CARDOZA
                     Central Virginia Governor's School

Honorable Mention: KATHERINE E. HUNOLD
                     Mills E. Godwin High School

Honorable Mention: CHELSEA A. LIVINGSTON
                     Deep Run High School

Third Place: GREGORY E. TITO
                     George H. Moody Middle School

Second Place: HUNTER A. JOSEPH
                     Shenandoah Valley Governor's School

First Place: LEAH J. HENDRIX
                     Chesapeake Bay Governor's School

SPECIAL AWARDS

Botany Section Award, given by the Botany Section of the VAS, to the best paper on a botanical subject. ($150.00)

LAURA K. LONG
Roanoke Valley Governor's School

VJAS Neuroscience Awards supported by the Virginia Neurological Society is given to an out-standing paper in the field of neuroscience ($100).

ANDREW P. BROWN
Yorktown High School

Mathematics Award for the paper that evidences the most significant contribution in the field of Mathematics. ($200.00)

ZECHARIAH ZIMMERMAN
Roanoke Valley Governor's School

Statistics Award for the paper that evidences the most significant contribution in the field of Statistics ($200.00)

ROHIT BANERJEE
Mills E. Godwin High School

Smith Shadomy Infectious Disease Award in honor and memory of Dr. Smith Shadomy given by the Virginia Chapter of the National Foundation of Infectious Diseases. ($50.00)

CHAO YIN
Yorktown High School

Roscoe Hughes Award for the best paper in the field of Cellular Biology ($150.00)

AMBER G. KUNKEL
Maggie L. Walker Governor's School

Rodney C. Berry Chemistry Award for the paper that evidences the most significant contribution in the field of chemistry.($200.00)

BENJAMIN M. SPENCE
Mills E. Godwin High School

The Dr. and Mrs. Preston H. Leake Award in Applied Chemistry will be given to the author of a research paper which best exemplifies how chemicals, chemical principles, or chemistry have been used, are used, or might be used to enhance or even to save life. ($200, $150)

Second Place   KATHLEEN E. FLEMING
                      Yorktown High School

First Place   SOHINI SIRCAR
                      Maggie L. Walker Governor's School

Russell J. Rowlett Award for the Best Research Paper of the Year. ($200)

JASON SHIELDS
New Horizons Governor's School

The Virginia Psychological Foundation Meritorious Research Awards recognize outstanding presentations of research in the various fields of psychology. Presented by *James P. O'Brien*. ($100 each for 4 winners)

ANDREW P. BROWN
Yorktown High School

LEE H. ELLIOTT
Central Virginia Governor's School

DAVID G. WISE
Mills E. Godwin High School

ANNE K. MINOFF
Yorktown High School

Virginia Sea Grant College Program Award is given by the Virginia Sea Grant College Program for outstanding marine or coastal research. ($100.00)

WILLARD T. OBER
Chesapeake Bay Governor's School

American Cancer Society Award - This award is to recognize outstanding science papers related to cancer research. A certificate to each and to 1st place - $200, 2nd place $100, HM $50. There will be a ribbon for each winner. These awards are provided by the American Cancer Society (Virginia Council). These awards are being presented by *Susannah Whitener*, a community manager with the American Cancer Society serving the New River Valley and *Abigail Bartley*, Regional Development Director will present these awards

Honorable Mention	YU-SUNG HUANG Maggie L. Walker Governor's School
Honorable Mention	TAEHYUN RYU Bishop Denis J. O'Connell High School
Second Place	CHAO YIN Yorktown High School
First Place	SOHINI SIRCAR Maggie L. Walker Governor's School

The Gamma Sigma Delta Award (Agriculture). Presented by the VPI & SU Chapter of the Honor Society of Agriculture. This award is presented in recognition of excellence in research dealing with application of new technologies and/or concepts in agriculture forestry, or veterinary medicine. ($100)

JACQUELINE R. ADDESA
Central Virginia Governor's School

Dominion - W.W. Berry Award. This award is given by Dominion Virginia Power in honor of Mr. W. W. Berry who was a past Chairman of the Board of VA Power. This award of a $500.00 Savings Bond will be presented to the best engineering paper. The winners must see the Director by the stage after the awards ceremony.

ANMAR L. SIOCHI
Warwick High School

The Joyce K. Peterson Award is presented for the outstanding paper by a middle school student. It is presented in honor of Mrs. Joyce K. Peterson who has been an outstanding teacher in the Arlington County Schools. ($50)

APURVA PANDE
George H. Moody Middle School

The Ann M. Hancock Award - This award is given to the best paper in genetics and is given in memory of Anne Hancock who retired from Patrick Henry High School in Hanover County and who gave many years of service to the Jr. Academy not only by teaching but also serving on the Jr. Academy Committee. ($100)

> SOHINI SIRCAR
> Maggie L. Walker Governor's School

Dorothy Knowlton Award - This award is given to the best paper in the Consumer Science section(s) and is given in honor of Dorothy Knowlton, former Science Coordinator of Arlington County Schools. ($50)

> ELIZABETH GENTRY
> Atlee High School

VABE Award - This award is presented by the Virginia Association of Biology Educators and is given for outstanding research in the Zoology section. ($100)

> LEAH J. HENDRIX
> Chesapeake Bay Governor's School

Virginia Museum of Natural History Award - Presented by the Friends of the Virginia Museum of Natural History in recognition of significant contribution in the study and interpretation of Virginia's Natural Heritage. The winner will receive $100. This award will be presented by the VA Museum of Natural History Director, Tim Gette.

> WILLARD T. OBER
> Chesapeake Bay Governor's School

Trip to AJAS - AAAS Meeting for two students for presenting outstanding papers. The 2007 meeting will be held in Feb.in San Francisco. Please meet with the Director in front of the stage after the awards ceremony.

> Winner SOHINI SIRCAR
>   Maggie L. Walker Governor's School
>
> Winner ANDREW BROWN
>   Yorktown High School

Honorary Membership - AAAS given to two students.

TRISTAN HAYES
I.C. Norcom High School

KELLY O'BRIANT
Yorktown High School

Honorary Membership - VAS given to a student.

KELLY O'BRIANT
Yorktown High School

Bethel High School Scholarship - This $1,000 Scholarship Award comes from the interest earned from a $10,000 endowment contributed by the students of Bethel High School, Hampton, Va., over a two year period. This award is based on both the students presentation and paper.

GRETE C. KARUSO
Washington-Lee High School

TECH Scholarships - This year, Virginia TECH, the Virginia Junior Academy of Science host university, will offer three scholarships to students who have written an outstanding research paper and who will be attending VA TECH. Each scholarship is for $2,000.00.

The Thomas H. Jones Scholarship will be presented by *Dr. Richard G. Oderwald*, Associate Dean, College of Natural Resources.

HOLLY STAINBACK
Chesapeake Bay Governor's School

The Booker Scholarship for Entering freshmen in the College of Science is being awarded by *Dr. Jerry H. Via*, Assistant Dean, College of Science.

ABBY HUGHES
Chesapeake Bay Governor's School

The John Lee Pratt Scholarship is being awarded by *Dr. John Crunkilton*, Assistant Dean, College of Agriculture and Life Sciences.

AMANDA L. THOMAS
Prince Edward County High School

Henry MacKenzie Environmental Scholarship - This $5,000 scholarship will be awarded to the student whose paper evidences the most significant contribution in the field of Environmental Science dealing with the James River Basin and Chesapeake Bay. The Virginia Endowment and VJAS offer this scholarship in tribute to the outstanding and generous services of Judge Henry W. MacKenzie, Jr., one of the founding directors who has a great interest in the James River and the Chesapeake Bay.

ABBY M. HUGHES
Chesapeake Bay Governor's School

Frances and Sydney Lewis Environmental Scholarship: A $14,000 scholarship ($3,500 per year for four years) for the best effort by a student in grades 9 to 12 in the field of environmental science. This scholarship is in the name of Frances and Sydney Lewis and is given by the Virginia Environmental Endowment.

LEAH J. HENDRIX
Chesapeake Bay Governor's School

E.C.L. Miller Science Teacher of the Year Award is given to an outstanding science teacher. An all-expense-paid trip to the next VAST meeting held in November.

KAY SELISKAR
Swanson Middle School

VJAS Distinguished Service Award, most prestigious award given by the VJAS, is presented to a person for exceptionally outstanding service to the VJAS. This award is presented by Susan Booth.

JAMES (JIM) MARTIN
BARBARA (BOBBIE) WHITTIER

New Fellow
Robert A. Willis, Jr.

Robert A. Willis, Jr. has been named Fellow of the Virginia Academy of Science. He has been an active member of the Virginia Academy of Science and the Association of Departments of Computer, Information Science/Engineering at Minority Institutions (ADMI) for nearly fifteen years.

He has made many contributions to the Academy over the past fifteen years. The Computer Science Section of the Virginia Academy of Science was founded by Robert Willis and Gregory Cook in 1991. Bob was the first Chairman of that section and he served in that capacity for several years. He has contributed to that Section at the annual meetings by presenting papers, coauthoring papers with students, and sponsoring undergraduate and graduate computer science students from Hampton University and other ADMI colleges. He provided leadership as an officer in that section for several years as Chairman, Editor and Councilor. For example, in 1995 he brought four undergraduate students to present papers at the Computer Science Section meeting, which is not only significant in numbers for such a small section, but also in diversity since he and his students are African American. He has continued to bring students to the Annual Meeting and to encourage Hampton University faculty involvement in the Academy. Bob was named Councilor for the Computer Science Section in 1996, a position he has held for ten years.

In 1997, at the Annual Meeting held at Virginia Tech, Bob Willis was elected to serve on the Executive Council as Treasurer for 1997-98. He was named Editor of the Academy's Newsletter, *The Virginia Scientist*, in May 1998 and served in that capacity until July 2005 when his health and the time demands to maintain accreditation of his computer science program could no longer support the workload as editor. He was elected to the positions, President-Elect for 2000-2001 and President of the Virginia Academy of Science for 2001-2002. Robert Willis is the

first African American scientist to become President of the Virginia Academy of Science. He has also served on the Nominations and Elections and on the Publications committees for the Academy.

After a career in the Air Force, Robert Willis earned his Master of Science degree and completed additional post-graduate study in computer science at the College of William and Mary. He joined the faculty in the department of computer science at Hampton University in 1986. Bob has helped educate and train minority scientists in the computer and information science fields through his leadership roles in organizations and as the chairman of the department of computer science at Hampton University. He was awarded the Lindback Distinguish Teacher's Award, Hampton University's highest award for teaching, in 1990 and named to Who's Who Among America's Teachers five times in the past ten years.

Bob served on the Board of the Association of Department of Computer, Information Science/Engineering at Minority Institutions (ADMI) from 1997 to 2000 and as the Vice-President of Programs from 2000 to the present. In his various capacities in ADMI he has organized meetings to provide opportunities for minority students in computer science and engineering to present scientific papers and to network with other students and institutions. These institutions include several Historically Black Colleges and Universities (HBCU) in the Commonwealth of Virginia, in addition to others in the Southeast. He has also served as the Project Director for the HBCU Graduate Fellowship and HBCU/MI Summer Faculty Research Programs for the Office of Naval Research and has helped students and faculty from Virginia schools participate in these programs. He has made a significant impact on the education of minority students in preparing them for advanced degrees and research opportunities and on the research participation of computer and science and engineering faculty in the Virginia through those programs.

AUTHOR INDEX

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Three complete copies of each manuscript and figures are required. It is also required that authors include a diskette in PC compatible format containing a text file (ASCII or acceptable word processing file) of the manuscript. Original figures need not be sent at this time. Authors should submit names of three potential reviewers. All manuscripts must be double-spaced. **Do not** use special effects such as bold or large print.

The title, author's name, affiliation, and address should be placed on a cover page. An abstract (not to exceed 200 words) summarizing the text, particularly the results and conclusions, is required. The text should follow the general format used by professional journals in the author's discipline and the Virginia Journal of Science has an on-line style manual. Literature cited in the text should follow the name-year format: (McCaffrey and Dueser, 1990) or (Williams et al., 1990). In the Literature Cited section at the end of the article, each reference should include the full name of the author(s), year, title of article, title of journal (using standard abbreviations), volume number and first and last page of the article. For a book, include author(s), year, title, pages or number of pages, publisher and city of publication. Examples:

McCaffrey, Cheryl A. and Raymond D. Dueser. 1990. Plant associations of the Virginia barrier islands. Va. J. Sci. 41:282-299.

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Each figure and table should be mentioned specifically in the text. All tables, figures and figure legends should be on a separate pages at the end of the text.

Multiple author papers are required to have a statement in the acknowledgments indicating the participation and contribution of each author.

After revision and final acceptance of an article, the author will be required to furnish two error-free copies of the manuscript: 1) typed copy, single spaced, with tables and figure captions at the end of the document, and one set of original figures, each identified on the back by figure number and author's name; 2) a diskette in a PC compatible format containing the text file, tables and figure legends.

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Year-round Diet of the Marsh Rice Rat, *Oryzomys palustris*, in Virginia Tidal Marshes

Robert K. Rose[1] and **Shannon Wright McGurk**

Department of Biological Sciences, Old Dominion University, Norfolk, Virginia 23529-0266

ABSTRACT

The marsh rice rat, *Oryzomys palustris,* is the dominant semi-aquatic rodent living in tidal marshes of the Virginia coastal plain. Described as highly carnivorous, this species is known to consume a range of animal foods, including crustaceans, mollusks, fish, and arthropods, as well as some plant foods. Analysis of stomach contents from rice rats collected from Eastern Shore tidal marshes throughout an annual cycle revealed that all 103 stomachs contained dicots, 82 percent had monocots, 61 percent had crabs and insects, and 38 percent had snails. Thirty-eight percent of stomachs contained foods in all five categories, no stomach was empty or contained fish, and 84 percent of stomachs had amounts of hair, probably ingested during self-grooming. In sum, Virginia rice rats are carnivorous but consume greater amounts of plant foods compared to populations that have been studied in Georgia and Louisiana.

INTRODUCTION

The marsh rice rat, *Oryzomys palustris*, is a semi-aquatic rodent with its highest abundances in wet fields and marshes, mostly of the southeastern US (Wolfe 1982). Distributed along the eastern seaboard southward from coastal Pennsylvania to the tip of Florida and westward to Corpus Christi, Texas, its range extends northward along the Mississippi River basin into southern Missouri and Illinois. In Virginia, it is common in tidal marshes of the coast and Chesapeake Bay and is present in some grassland habitats as far west as the fall line (ca. Interstate Highway 95; Linzey 1998). The marsh rice rat readily takes to water to forage and escape from predators, and can be caught in floating live traps (personal observation, RKR). Its swimming ability has been studied by Esher et al. (1978) in Mississippi and Carter and Merritt (1981) in Virginia, and inter-island movements of marked rice rats have been documented for the Virginia barrier islands (Forys and Dueser 1993). Medium in size among rodents (up to 80 g), *Oryzomys* is considered to be highly carnivorous, second to North America's most carnivorous rodent, the grasshopper mouse, *Onychomys*, a desert grassland mouse of the western states. The meat-eating proclivities of marsh rice rats were observed by Schantz (1943), who reported them eating the bodies of trapped muskrats, a behavior also observed by RKR (unpublished) on trapped small mammals on Fisherman Island, Virginia. The natural history of the marsh rice rat is summarized in Wolfe (1982).

[1] Corresponding author: Robert K. Rose, Department of Biological Sciences, Old Dominion University, Norfolk, Virginia, Phone: 757-683-4202, Email: brose@odu.edu

The objectives of our year-long study were to learn the kinds and proportions of foods eaten by marsh rice rats taken from tidal marshes of the Eastern Shore of Virginia and their seasonality of food selection. *Oryzomys palustris* is codominant in these tidal marshes with the meadow vole, *Microtus pennsylvanicus* (March 1995, Bloch and Rose 2005), with the latter being almost exclusively herbivorous (Zimmerman 1965, among others). Where the diet of marsh rice rats has been examined in Louisiana (Negus et al., 1961), Florida (Pournelle, 1950) and Georgia (Sharp, 1967), *Oryzomys* consumes both plant and animal materials, in differing proportions. In our study, we learned that Virginia rice rats ate higher proportions of plant material than at other geographic locations, plus varying amounts of crabs, snails, and arthropods (mostly insects).

MATERIALS AND METHODS

The Study Area

This study was conducted over a one-year period, from May 1994-April 1995. The research goal was to collect samples of up to 15 animals each month from two seaside sites in Northampton County, Virginia, one located ca. 300 m south of Oyster and the other 500 m east of Townsend. In October, an opportunity was presented to examine animals from the marshes of nearby barrier islands (Myrtle, Ship Shoal, Smith, and Mockhorn), so the sample size for that month was much larger than the others. For unknown reasons, rice rats were scarce during the summer months of June-August, and only two animals were collected during that time (Table 1), despite an increased trapping effort then compared to other months. March (1995), in earlier studies of the population dynamics of rice rats in similar tidal marshes on the Eastern Shore, had also found density to be low or near zero in June and July, and Negus et al. (1961) caught 13 rice rats in July in 2145 trap-nights and 3 in June of another year in 504 trap-nights, both < 1 rice rat per 200 trap-nights, indicating behavioral or other changes lowering their trappability in summer.

Both study sites were in tidal marshes backed by areas of dense common reed, *Phragmites australis*. The flora of the marshes included *Spartina alterniflora* (salt grass), *S. patens* (salt meadow hay), *Panicum* sp. (panic grasses), *Juncus roemeranius* (black needle-rush), *Salicornia* sp. (glasswort), *Baccharis halimifolia* (saltbush), and *Typha latifolia* (cattail). Both marshes are flooded twice daily in the area of the *Juncus*, whereas the *S. patens* areas are flooded only during monthly high or wind tides. The border between *Baccharis* shrubs and *Juncus* often supported a more substantial wrack line than that between *S. patens* and *Juncus*. This wrack line provided additional structure to a marsh with relatively little structure, except for the *Baccharis* shrubs.

Trapping and Laboratory Procedures

Transects of Fitch live traps (Rose 1994) were placed 2-3 m apart along the borders, i.e., at the normal extent of the daily high tide. Baited with wild birdseed and tended early each morning, these traps yielded mainly marsh rice rats and meadow voles, with lesser numbers white-footed mice (*Peromyscus leucopus*) and house mice (*Mus musculus*), and even fewer least shrews (*Cryptotis parva*) and short-tailed shrews (*Blarina brevicauda*). Only marsh rice rats were collected for this study. Marsh rice rats were returned to the laboratory, euthanized by chloroform anesthesia, and frozen.

TABLE 1. For each sex, sample sizes of the age categories of rice rats, following the criteria of Negus et al. (1961).   Age category 1 = juvenile, 2 = subadult, 3 = near adult, and 4 = adult. The months have been grouped into seasons, with June-September SUmmer, October and November AUtumn, December-February WInter, and March-May SPring.

MONTH	TOTAL #	# FEMALES	# MALES	AGE 1	AGE 2	AGE 3	AGE 4
May SP	6	1	5	2	0	0	4
June SU	1	1	0	1	0	0	0
July SU	0	0	0	0	0	0	0
August SU	1	1	0	1	0	0	0
September SU	7	1	6	2	2	1	2
October AU	36	10	26	8	8	3	17
November AU	3	2	1	3	0	0	0
December WI	9	4	5	5	1	3	0
January WI	15	6	9	12	0	2	1
February WI	12	7	5	7	2	2	1
March SP	9	2	7	1	0	4	4
April SP	4	0	4	0	1	0	3
Totals	103	34	69	41	14	15	33

In order to compare what was eaten with what foods were available, samples of all potential food sources in the tidal marshes were collected from the same marshes as the rice rats, returned to the lab, processed, and made into reference slides.   After samples of plant and animal materials had been pulverized in a Waring® blender to a consistency comparable to that of stomach contents of rice rats, the material then was washed in water, air-dried, and placed on microscope slides with Kleermount, a mounting medium, and covered with standard coverslips. Reference slides were made of three dicots (*Baccharis, Salicornia,* and *Typha*), four monocots (*Juncus, Panicum* sp., *Spartina alternifolia,* and *S. patens*), and four animals: fiddler crab, *Uca minax;* periwinkle, a univalve snail, *Littorina irrorata;* mummichog, a small brackish-water fish, *Fundulus heteroclitus;* and several arthropods, including grasshoppers, crickets, flies, and spiders, hereafter called 'insects'.

After the rice rats were thawed, standard measurements were taken (total length, lengths of tail, foot and ear, body mass) and the reproductive information was recorded for a related research project (Dreelin 1997).   The contents of each stomach were removed, washed in water, air-dried, and then placed in separate 10-ml beakers, covered, labeled, and placed in the freezer to avoid contamination. For analysis, two samples from each stomach were placed on two slides with Kleermount, covered with standard coverslips, and compared to reference slides (method modified from Fleharty and Olson 1969).   The contents were analyzed using a percent volume method, in which the amount of each type of food was visually estimated using a standard 10 X 10 ocular grid (Whitaker and French 1984).   Food items were identified as belonging to one of six categories: dicotylenous plant, monocotyledonous plant, crab, snail, fish, and arthropod.   In each of the 10 randomly selected 10 X 10 ocular fields, the volume of each food type was estimated and recorded.   The volumes from both slides of each stomach were then summed, and an average was calculated to determine the percent volume of each food type for each stomach.

TABLE 2. Mean percent volumes and standard errors (in parentheses) based on examination of 10 microscopic fields in each of two slides per marsh rice rat, using the technique of Whitaker and French (1984). Values are given for each month of study and for each food category.

MONTH	DICOT	MONOCOT	CRAB	SNAIL	INSECT
May	77.2 (0.11)	8.1 (0.07)	7.1 (0.08)	3.7 (0.07)	4.0 (0.07)
June	95.8 (----)	4.2 (----)	0.0 (----)	0.0 (----)	0.0 (----)
July	--- (----)	--- (----)	--- (----)	--- (----)	--- (----)
August	73.4 (----)	10.9 (----)	4.2 (----)	0.0 (----)	11.5 (----)
September	79.5 (0.05)	9.2 (0.02)	6.1 (0.06)	2.9 (0.04)	2.1 (0.03)
October	66.1 (0.04)	12.0 (0.04)	6.8 (0.03)	3.9 (0.03)	11.3 (0.04)
November	76.8 (0.08)	4.9 (0.05)	11.6 (0.11)	3.6 (0.07)	3.2 (0.05)
December	85.4 (0.08)	6.8 (0.06)	4.6 (0.06)	1.7 (0.02)	1.5 (0.03)
January	75.8 (0.05)	10.5 (0.04)	6.6 (0.04)	6.0 (0.04)	1.1 (0.01)
February	75.7 (0.06)	16.9 (0.05)	3.7 (0.03)	2.3 (0.03)	1.4 (0.02)
March	62.3 (0.07)	30.1 (0.05)	0.2 (0.09)	7.0 (0.01)	0.4 (0.01)
April	70.2 (0.11)	25.5 (0.12)	0.2 (0.02)	0.9 (0.01)	3.2 (0.06)

RESULTS

Eastern Shore rice rats consumed dicots, monocots, crabs, snails, and insects (Table 2), but no fish were detected in any stomach. Dicot food was always most important, with most monthly values in the 70-85 percent range and the extremes being 62.3 percent (March) and 95.8 percent (June). The highest values for monocots were from the spring months of March (30.1 percent) and April (25.5 percent), months with low values for dicots (Table 2). The lowest value for monocots was in June, also the only month when no animal foods were detected in the stomach of the one rice rat that constituted the sample for that month. The monthly consumption of each animal food class was highly variable, ranging from fractional amounts to high values of 11.6 percent (November) for crabs, 7.0 percent (March) for snails, and over 11 percent for insects (August and October). The total amounts of animal foods likewise were highly variable, with lows of 4.3 percent in April and just over 7 percent in February and March and highs in August and October (16 and 22 percent, respectively).

During the period when breeding begins, late winter/early spring, monocot foods were relatively more important than at other times. However, because of the great monthly variation in proportions of consumption of each food class, no other patterns were evident. Eighty-four percent of stomachs contained some amount of hair, hairs of a type possessed by marsh rice rats and house mice. However, because no evidence of bone fragments was found in any stomach, we believe the hairs were the result of self-grooming rather than from cannibalism or predation on house mice.

DISCUSSION

Negus et al. (1961) determined that total length was the best surrogate of age. Using their criteria for four age classes, the percentages of animals we observed in each age category were 40 (for juveniles), 14, 15, and 32 percent, respectively (Table 1). The study of Negus et al. (1961), which included seven intervals of trapping ranging from one to four months spread over 30 months, reported percentages of rice rats in the same age categories of 17, 24, 14, and 46 percent, respectively. Thus, our population

had a larger proportion of juveniles and a smaller proportion of adults compared to the Louisiana populations.

Most of the available kinds of food in the study area were found in the stomachs of marsh rice rats. Plant material was found in all stomachs, with 100 percent containing dicots and 82 percent with monocots. Crabs, snails, and insects were found in 61, 38, and 61 percent, respectively, of stomachs. Thirty-eight percent of stomachs had foods from all five food categories, no stomach was empty, and no fish remains were detected.

Dicots were the staple in the diet of marsh rice rats in Virginia tidal marshes, ranging from 62.3-95.8 percent (Table 2). Of the dicot foods, *Salicornia* was found mostly in patches on tidal flats, whereas *Typha* and *Baccharis* were located farther landward. Across the year, dicots constituted a mean percent volume of 76.2 percent of the contents of the 103 stomachs. This consumption rate of dicots was much higher than that reported for marsh rice rats in Louisiana (43%; Negus et al. 1961) or in Georgia (24%; Sharp 1967). For reasons that are not immediately evident, we conclude that dicots are relatively much more important to Virginia animals than to more southerly populations of marsh rice rats.

Monocots were next in importance, with monthly volumes ranging from 4.2-30.1 percent. All monocot foods were found in patches throughout the marshes, with *Juncus* being present in greatest abundance, followed by *Spartina patens, S. alternifolia,* and *Panicum* in that order. These four plants constituted a mean percent volume of 12.6 percent of the diet across the year. Seasonal mean percent volumes for monocots were lower during summer (6.1%) and autumn (4.5%) than in winter (11.4%) and spring (21.3). The high values in winter and spring suggest that monocots provide the calories for increased heat production during these seasons when large amounts of heat are lost to the environment and other foods either may be energetically more costly to obtain (crabs and snails) or are not as available (insects) as during other seasons.

Fiddler crabs were present in the diet in 10 months, i.e., in every month with a sample size >1. Fiddler crabs were present throughout the marsh, with highest numbers on the tidal flats. Volumes of crabs in the diet ranged from 2.5 percent in spring to 9.2 percent in autumn, with summer and winter volumes of 2.6 and 5.0 percent, respectively, and the total mean percent volume for crabs from all stomachs was 4.6 percent. Similar volumes were consumed in all seasons.

Snails likewise were eaten in every month when sample size exceeded 1. Snails were found throughout the marsh but also had highest numbers on tidal flats, where they cling exposed on standing vegetation during the hours when the tide is out. Thus, they are especially vulnerable to predators at this time. Volumes of snails in the diet ranged from 0.7 percent during summer to 3.9 percent in spring. The mean percent volume of snails for all stomachs was 2.9 percent, the lowest of all food categories.

Insects also were consumed every month with sample size >1, with volumes ranging from 0.5 (summer) to 7.3 (autumn) percent among seasons; winter and spring volumes were 1.3 percent and 2.5 percent, respectively. This variation among seasons no doubt reflects availability patterns. The overall mean percent volume of insects was 3.6 percent, making insects just slightly higher in importance than snails as consumed foods.

The marsh rice rat chooses a diet higher in energy (insect food) as it loses more heat to the environment when temperatures decline. This may help explain why crabs ranked second in importance for November, an autumn month, and why crabs remained the most important animal food during the winter months too. Overall, the bulk of calories consumed by Virginia marsh rice rats were derived from plant foods but animal foods were particularly important during the colder months. Although Negus et al. (1961) contend that Louisiana rice rats consume mostly insects and fungi, and few vegetative parts in winter, their Figure 10 shows highest amounts of insects in May and August, comprising 65 and 75 percent, respectively, of the diet. Negus et al. (1961) found substantial amounts of mycelial threads of the fungus *Endogone* in the stomachs of February, May, and November samples, as well as fish and snails in December. Thus, rice rats living in sedge meadows in Louisiana are more carnivorous and have more catholic diets than those living in Virginia tidal marshes.

Sharp (1967), who examined the stomach contents of *Oryzomys palustris* collected in summer from Georgia salt marshes, found that rice rats fed almost exclusively on insects and small crabs. Of 13 rice rats from July and August, insects were dominant in 10 and crabs in three animals; except for one stomach with a trace of plant material, all other stomachs had no plant remains. Larvae of the rice-borer (*Chilo* sp.), extracted from the hollow stems of *Spartina* grasses, and *Uca* and *Sesarma* crabs constituted the bulk of foods in the stomachs (Sharp 1967). In the lab, Sharp found that *O. palustris* could not survive when given only vegetable foods, indicating the need for a varied diet.

The hairs in the stomachs of Virginia rice rats were probably from self-grooming activities. Svihla (1931) described in detail the body-cleaning and grooming activities of rice rats and Hamilton (1946) observed rice rats engaging in the longest bouts of personal grooming he had ever seen in small mammals. This attention to the pelage likely is related to its water-repellant properties. When a rice rat dives and swims, a bubble of air separates its pelage from the water, and when the animal emerges its pelage quickly sheds water droplets, revealing a dry and prime coat.

In conclusion, marsh rice rats in Virginia tidal marshes have diets consisting mainly of plant foods which they supplement in every month and season with varying amounts of crab, snail, and insect foods, but no fish. Animal foods vary in availability throughout the year, and are relatively more important in the diet in autumn and winter than at other seasons. Dicots are the most important class of food in every month, with the proportions of monocots being greatest in late winter and spring.

LITERATURE CITED

Bloch, C. R., and R. K. Rose. 2005. Populations dynamics of *Oryzomys palustris* and *Microtus pennsylvanicus* in Virginia tidal marshes. Northeastern Naturalist 12:296-306.

Carter, J. L., and J. F. Merritt. 1981. Evaluation of swimming ability as a means of island invasion by small mammals in coastal Virginia. Annals of Carnegie Museum 50:32-45.

Dreelin, E. A. 1997. The annual reproductive cycle of *Oryzomys palustris* in a Virginia tidal marsh. M. Sc. Thesis, Old Dominion University, Norfolk, Virginia. 46 pp.

Esher, R. J., J. L. Wolfe, and J. N. Layne. 1978. Swimming behavior of rice rats (*Oryzomys palustris*) and cotton rats (*Sigmodon hispidus*). Journal of Mammalogy 59:551-558.

Fleharty, E. D., and L. E. Olson. 1969. Summer food habits of *Microtus ochrogaster* and *Sigmodon hispidus*. Journal of Mammalogy 50:475-486.

Forys, E. A., and R. D. Dueser. 1993. Inter-island movements of rice rats (*Oryzomys palustris*. American Midland Naturalist 130:408-412.

Hamilton, W. J., Jr. 1946. Habits of the swamp rice rat, *Oryzomys palustris palustris* (Harlan). American Midland Naturalist 36:730-736.

Linzey, D. W. 1998. The mammals of Virginia. McDonald & Woodward Publishing Company, Blacksburg, Virginia. 459 pp.

March, J. A., Jr. 1995. Population dynamics of *Oryzomys palustris* and *Microtus pennsylvanicus* on the Eastern Shore of Virginia. M. S. Thesis, Old Dominion University, Norfolk, Virginia. 61 pp.

Negus, N. C., E. Gould, and R. K. Chipman. 1961. Ecology of the rice rat, *Oryzomys palustris* (Harlan) on Breton Island, Gulf of Mexico, with a critique of social stress theory. Tulane Studies in Zoology 8:93-123.

Pournelle, G. H. 1950. Mammals of a north Florida swamp. Journal of Mammalogy 31:310-319.

Rose, R. K. 1994. Instructions for building two live traps for small mammals. Virginia Journal of Science 45:151-157.

Schantz, V. S. 1943. The rice rat, *Oryzomys palustris,* in Delaware. Journal of Mammalogy 24:104.

Sharp, H. F., Jr. 1967. Food ecology of the rice rat, *Oryzomys palustris* (Harlan), in a Georgia salt marsh. Journal of Mammalogy 48:557-563.

Svihla, A. 1931. Life history of the Texas rice rat (*Oryzomys palustris texensis).* Journal of Mammalogy 12:238-242.

Whitaker, J. O., Jr., and T. W. French. 1984. Foods of six species of sympatric shrews from New Brunswick. Canadian Journal of Zoology 62:622-626.

Wolfe, J. L. 1982. *Oryzomys palustris*. Mammalian Species 176:1-5.

Zimmerman, E. G. 1965. A comparison of habitat and food of two species of Microtus. Journal of Mammalogy 46:605-612.

A Decade of Changes for Virginia Freshwater Aquaculture (1993 – 2003)

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ABSTRACT

Aquaculture surveys were designed and initiated along with the writing of the State Aquaculture Plan during 1993 to 1995. The first Virginia Aquaculture Survey, conducted for the production year 1993, established the status of both freshwater and marine commercial industries. Subsequent surveys were conducted to trace industry developments relevant to production aspects and economic impacts. Survey data from Virginia Agricultural Statistics Service Reports for 1993, 1995, 1997, and 2003 summarize a decade of Virginia freshwater aquaculture information. Significant changes in sales among the principal aquaculture species occurred over the 10-year period. The 1993 freshwater aquaculture value of $2.8 million increased to $6.0 million in 2003; however, the increase was due to $4.2 million in tilapia sales. Thus, the balance of $1.8 million is actually a decrease by $1 million for 2003 sales when compared to 1993. Losses in trout sales account for the $1 million decrease in 2003. Catfish and hybrid striped bass production and sales remained low and declined during the 10-year period.

INTRODUCTION

Prior to the mid-1980s, Virginia freshwater aquaculture production was limited primarily to rainbow trout (*Oncorhynchus mykiss*). During that era, freshwater trout sales for live stocking in private streams and commercial markets are estimated to have been less than $2 million annually. Beginning in the late-1980s, a period of growth and development with warm water aquaculture began as a result of research and extension program emphasis at Virginia State University (VSU) and Virginia Polytechnic Institute and State University (VPI) universities. State funding for aquaculture activities in the Commonwealth commenced with the "Aquaculture Initiative" in 1987. Hybrid striped bass (*Morone saxatilis* x *M. chrysops*) and channel catfish (*Ictalurus punctatus*) were the primary species studied for commercial production in farm pond and cage culture operations. Aquaculture research was conducted concurrently at Virginia's land grant universities, cooperatively with other institutions and government agencies.

The Virginia Department of Agriculture and Consumer Services (VDACS) developed an Aquaculture Plan for the Commonwealth of Virginia beginning in 1993 (Newton 1995). As a result of activities associated with the State Plan, the first Virginia Aquaculture Survey was conducted for the production year 1993. Goals of this comprehensive state survey were to determine the status and to establish a production benchmark for both freshwater and marine aquaculture industries. Subsequent surveys were conducted to follow aquaculture growth and related developments effecting industry value and agricultural impacts.

Three additional surveys have been conducted since 1993 that have updated Virginia freshwater and marine aquaculture production and sales. Virginia aquaculture production was included in a national census of aquaculture by the U. S. Department

of Agriculture, National Agricultural Statistics Service (NASS 2000). Virginia ranked number ten in the 1998 Census Report with nearly $25 million in sales primarily because soft-shell crabs (*Callinectes sapidus*) were considered to be an aquaculture product. If soft-shell crabs were not considered to be aquaculture products, Virginia would not be listed as a top aquaculture producing state.

METHODS

Formats of subsequent survey instruments were similar to the original instrument developed at the time of the State Aquaculture Plan by Jim Lawson, Deputy State Statistician, Virginia Agricultural Statistics Service (VASS) and the author. Surveys were conducted by VASS using mailings, telephone calls, and farm site visits to contact producers. All data provided by industry are protected by confidentiality regulations established by the U. S. Department of Agriculture and the National Agricultural Statistics Service (USDA regulations, Title 7, Chapter 55, Section 2276). Virginia Aquaculture Survey Reports for 1993, 1995, 1997, and 2003 are available from the Virginia Agricultural Statistics Service (K. Barnes, State Statistician, VASS, Richmond, Virginia, personal communication). Because of the small number of producers for various secondary species, VASS designated an "All Other Species" category that included tilapia sales with bait fish, ornamental fish, game fish, grass carp (*Ctenopharyngodon idella*), crayfish (*Procambarus* spp.) and other aquatic products. The Virginia Department of Game and Inland Fisheries application for tilapia importation lists four species and their hybrids allowed in the state. Unfortunately, applicants often just list *Tilapia spp.* or hybrid tilapia if they do not know what they are importing (Mr. Ron Southwick, Assistant Chief of Fisheries (for Aquaculture), Virginia Department of Game and Inland Fisheries, Richmond, Virginia). Information from Survey Reports was used to make comparisons, observations, and interpretations as they related to changes that occurred in Virginia aquaculture over a 10-year period. Because pounds were the unit of measure for food fish sales in the Reports, as well as the system used by industry, this article has maintained the same system to facilitate industry accessibility.

RESULTS AND DISCUSSION

The Virginia Agricultural Statistics Service has tracked the Virginia aquaculture industry by conducting producer surveys since 1993. Each Survey Report has provided information on both marine and freshwater industry sales. A review of freshwater aquaculture sales from 1993 to 2003 reveals the greatest increase in sales occurred soon after passage of the 1992 Virginia Aquaculture Development Act (Table 1). The Aquaculture Development Act also established a Governor appointed Aquaculture Advisory Board. The Virginia Aquaculture Plan was developed beginning in 1993 and published in 1995 by the Virginia Department of Agriculture and Consumer Services. Also, several industry producer associations were formed during the early 1990s. These activities had a positive impact upon aquaculture awareness and encouraged significant expansion of aquaculture during the mid-1990s (Newton 1995).

Production and sales comparisons for cultured species indicated that the principal freshwater species are channel catfish, hybrid striped bass, rainbow trout, and tilapia. Production and sales information for "all other species," which also included tilapia in the 1995, 1997, and 2003 Surveys were grouped by VASS due to USDA privacy

concerns and disclosure regulations. These concerns (USDA Title 7, Chapter 55, Section 2276) required tilapia sales to be combined with the "all other aquaculture species group," which includes ornamental, game fish, baitfish and other aquatic sales.

A statewide Aquaculture Initiative in research and extension started in 1987 through designated funding by the Virginia General Assembly. The Initiative began with funds for VSU, VPI, and Virginia Institute of Marine Science (VIMS) to provide research and extension support for aquaculture industry development in the Commonwealth. Hybrid striped bass was designated the "species of interest" for aquaculture production in the Commonwealth. Support for hybrid striped bass was primarily due to a low and declining population of native striped bass in the Chesapeake Bay. At about the same time, there was increasing popularity with hybrid striped bass for both recreational fishing and farm-raised food fish production. Striped bass domestication and hybridization research also was underway in other southern states during this time (Newton and Nerrie 1989). Survey data indicate that hybrid striped bass gross sales averaged $ 30,844 for the 4 years in which surveys were conducted (Table 1). The percentage of total freshwater sales for bass has remained very low and declined from 1.3% in 1993 to 0.5% in 2003.

Based upon the 1993 through 2003 surveys, catfish production averaged 19,000 pounds annually, with $30,797 average gross sales (Table 1). Overall, the catfish percentage of total freshwater sales has remained very low and declined from 1.2% in 1993 to 0.4% in 2003. In contrast to catfish farming in more southern states, Virginia aquaculture production has been limited to small operations in farm ponds or small cages floated in farm ponds. No large-scale catfish production facility has been developed in Virginia. Marketing has consistently been blamed for lack of growth among Virginia catfish operations, thus hesitancy remains toward new investments beyond small-scale operations.

Trout production declined from just over one million pounds annually during 1993 to 1997 to approximately 670,000 pounds for the 2003 report year (Table 2). Causes for production declines during this 6-year period are believed to be due to: 1) a series of drought years, 2) an increase in restrictive regulations, and 3) facilities going out of business. Gross sales of trout declined from a steady $2.3 million during the 1990s to $1.3 million for the year 2003, with the decline in sales directly related to production decreases.

Tilapia production soared during the 10-year period, to become the number one freshwater aquaculture species produced and sold in the Commonwealth of Virginia. Reported sales of tilapia began with the figure of $27,000 in 1993. Based upon study of the Survey Reports and the author's experience with Virginia aquaculture, it is estimated that the "all other aquaculture species group" sales have averaged about $500,000 for the years 1995, 1997, and 2003. Thus, by subtracting this figure within each Report, tilapia sales have shown an almost 50% increase from $2.3 million in 1995 to $4.2 million in 2003 (Table 2). These estimates are somewhat similar to North Carolina reports, where tilapia sales were about $3 million in 2004 (T. Losordo, Aquaculture Extension Specialist, North Carolina State University, personal communication). The percentage decline in trout from 81% of freshwater sales in 1993 to 22% in 2003 was offset by an increase in tilapia sales by over 70% for the 2003 report year (Table 1). The decrease in reported trout sales by $1 million in 2003 is believed to be independent of increases in tilapia sales. Trout and tilapia sales were

TABLE 1. Gross freshwater aquaculture sales as reported by Virginia Agricultural Statistics Service Surveys (m = million). Tilapia sales for 1995 1997, and 2003 based on an estimate of $500,000 in sales, each year, for "Tilapia & all others" which includes ornamental and baitfish.

Survey Year	Gross Sales in Dollars						Percentage of Total Gross Sales			
	Total Sales	Hybrid Striped Bass	Channel Catfish	Trout	Tilapia	Tilapia & Others	Hybrid Striped Bass	Channel Catfish	Trout	Tilapia[1]
1993	$2.8m	$35,846	$23,896	$2.3m	$27,150	$432,310	1.3	1.2	80.8	0.8
1995	$5.2m	$41,986	$33,035	$2.3m	$2.3m	$2.8m	0.8	0.6	44.0	44.0
1997	$5.3m	$16,782	$36,173	$2.3m	$2.5m	$3.0m	0.3	0.7	43.4	47.1
2003	$6.0m	$28,791	$21,087	$1.3m	$4.2m	$4.7m	0.5	0.4	21.6	69.9

[1]Estimated.

about the same in 1995 and 1997, however, reported tilapia sales were more than three times higher than trout sales in 2003 (Table 1).

There was no general pattern related to the levels of intended production increases documented in each survey (Table 2). For instance, hybrid striped bass production has not developed by the large percentages indicated, especially the 592% increase projected for the future in 1997. In contrast, tilapia production has increased far beyond the 1% projection indicated in the 2003 survey Report.

Industry Production Losses:

The four major causes of freshwater industry losses were weather, water quality, disease, and predation (Table 3). These factors are inter-related, because each of these losses may be affected or influenced by the other causes. For example, poor water quality can increase the severity of certain diseases. Also, there is no control over weather losses; either floods or drought can cause major fish losses, especially for trout producers. On average, predation accounts for approximately one-fifth of all freshwater losses. This is a category where control measures are usually costly relative to benefits gained.

In many cases, fish losses result from protected predatory species; this is particularly the case with herons, cormorants, waterfowl, and other migratory birds. Supplemental information regarding industry concerns was received on surveys during the expansion era of the 1990s. Anonymous comments were received from 25 percent of the producers surveyed in 1993, 1995, and 1997. Comments were reviewed and provided to the Aquaculture Advisory Board, industry producer associations, and government agencies to further assist with aquaculture growth and development in the Commonwealth (Newton and Lawson 1998).

Primary Aquaculture Species:

Hybrid Striped Bass

The largest sales year reported for hybrid striped bass was $42,000 in 1995. Percentage of total freshwater sales has ranged from 1.3% in 1993 to 0.3% in 1997. Production and sales figures (Table 2) reveal that hybrid striped bass culture has not developed as expected in Virginia. In contrast to Virginia industry sales, the North Carolina hybrid striped bass industry value was $7 million in 2004 (T. Losordo, Aquaculture Extension Specialist, North Carolina State University, personal communication). The primary difference between Virginia and North Carolina hybrid bass production is related to the water source. The Castle-Haynes aquifer used to produce North Carolina hybrid striped bass is an excellent ground water source that has high mineral content and low salinity. In contrast, hybrid bass production in Virginia is compromised in low alkalinity, soft-water farm ponds.

Channel Catfish

Reported catfish production was consistently low over the ten-year survey period. Percentage of total freshwater sales for catfish declined from a low level of 1.2% in 1993 to 0.4% in 2003. Even if production intentions of a 38% increase for 2004 are met, total gross sales will be raised by only $8,000. Total dollar value increase projected for hybrid striped bass and catfish combined is approximately $15,000 for the 2004 production year. This would raise the industry value for these two warm water aquaculture species to approximately $65,000. In stark contrast, the combined 2004 value reported by North Carolina for catfish and bass was $32 million (T. Losordo, Aquaculture Extension Specialist, North Carolina State University, personal

TABLE 2. Production and intended increases in production of freshwater aquaculture species as reported in Virginia Agricultural Statistics Service surveys (m = million). Hybrid striped bass production was not reported in 2003.

	Pounds Produced			Percentage Intended Production Increases			
Survey Year	Hybrid Striped Bass	Channel Catfish	Trout	Hybrid Striped Bass	Channel Catfish	Trout	Tilapia[1]
1993	13,137	22,270	1.2m	241	223	7	10
1995	11,750	16,695	1.2m	245	9	6	59
1997	5,128	19,503	1.1m	592	17	1	115
2003	----	17,721	670,000	24	38	12	1

1 Estimated

communication). The Virginia aquaculture industry would be well served by exploring the reasons behind this huge difference in industry values between adjoining states.

Rainbow Trout

Rainbow trout culture is the oldest established freshwater aquaculture industry in Virginia and the United States. Rainbow trout is the principal cultured species; however, brook trout (*Salvelinus fontinalis*), the only trout native to Virginia, brown (*Salmo trutta*), and golden rainbow trout (*O. mykiss aquabonita*) (Nelson, *et al.* 2004) are also produced in Virginia. From the late 1980s into the mid-1990s, gross sales of freshwater trout were steady at about $2.3 million annually (Table 1). A decline in production and sales occurred during 1997 to 2003. Annual sales reported for 2003 was down one million dollars from previous report years. The percentage decrease in trout sales has been offset by an increase in tilapia sales. Although trout sales have decreased to $1.3 million, the industry contribution is still large when compared with the combined sales of hybrid bass and catfish at $50,000.

Tilapia

Tilapia and rainbow trout have traded places with regard to percentage and volume of freshwater sales in Virginia. Tilapia sales increased by $4 million from 1993 to 2003, while trout sales decreased by $1 million dollars from 1993 to 2003. In North Carolina, where tilapia may be reared in ponds as well as indoor facilities, sales were about $3 million in 2004. As stated earlier, most Virginia tilapia production is by only a few large producers. At this writing, tilapia is the number one freshwater aquaculture species produced and sold in the Commonwealth of Virginia. Nationally, tilapia imports were 249 million pounds in 2004, up 25% over 2003 and 68% higher than 2002. The amount of foreign produced tilapia required to supply the U. S. market was about 500 million pounds of live fish in 2004 (Harvey 2005).

All Other SpeciesSales of baitfish, ornamentals, game fish, and others in this category have remained stable over the 10-year report period with an estimated value

TABLE 3: Percentage of freshwater aquaculture losses by cause.

Cause of Fish Loss	1993	1995	1997	2003
Weather	15	10	48	12
Water quality	20	12	4	9
Predation	15	18	18	26
Disease	17	25	24	35
Theft	8	--	--	1
All Others	25	35	6	17

of one-half million dollars annually. While most of these sales were from baitfish, an increase is expected in ornamental and game fish sales in the future.

CONCLUSIONS

Aquaculture surveys conducted from 1993 to 2003 reflect numerous changes in Virginia aquaculture. Currently, the principal freshwater aquaculture species, ranked according to sales value, are tilapia, rainbow trout, hybrid striped bass, and channel catfish. It is doubtful that unreported information would significantly change the remarkable trends revealed by comparison of these four surveys conducted over a decade. Rather, this series of surveys has set baselines and revealed industry trends. It is apparent that small-scale farm pond and cage operations with channel catfish and hybrid striped bass have yet to develop in Virginia. Rainbow trout sales have declined over 60% due to environmental and regulatory impacts. Tilapia dominates as the number one freshwater cultured species and remains in a growth phase for Virginia aquaculture. Therefore, more consideration of the reasons for the observed industry changes and of the present nature of the "small-scale approach" to aquaculture could enhance developments and help lead to successful establishment of aquaculture in the Commonwealth.

ACKNOWLEDGMENTS

LITERATURE CITED

Harvey, David. 2005. Aquaculture outlook bright for 2005. Fish Farming News. 12(3): 24-27 and 32.

NASS (National Agricultural Statistics Service)-. 2000. 1998 Census of Aquaculture. U. S. Department of Agriculture. AC97- P-3.

Nelson, J. S., E. J. Crossman, H. Espinosa-Perez, L. T. Findley, C. R. Gilbert, R. N.

Lean, and J. D. Williams. 2004. Common and scientific names of fishes from the United States, Canada, and Mexico. American Fisheries Society. Special Publication 29. Bethesda, MD.

Newton, Scott H. Editor. 1995. Virginia Aquaculture Plan. Virginia Department of Agriculture and Consumer Services. Richmond, VA. Vols. I and II. 205 pp.

Newton, Scott H. and Jim Lawson, 1998. Concerns and Problems Faced by Freshwater Aquaculture Producers in Virginia. Virginia Journal of Science. 49(2): 56.

Newton, S. H. and B. L. Nerrie, Eds. 1989. A Workshop on the Culture of Hybrid Striped Bass. Cooperative Extension, Virginia State University Press. 70 pp.

2004 JEFFRESS RESEARCH GRANT AWARDS

The Allocations Committee of the Thomas F. and Kate Miller Jeffress Memorial Trust has announced the award of Jeffress Research Grants to the institutions listed below to support the research of the investigator whose name is given. The Jeffress Trust, established in 1981 under the will of Robert M. Jeffress, a business executive and philanthropist of Richmond, supports research in chemical, medical and other natural sciences through grants to non-profit research and educational institutions in the Commonwealth of Virginia. The Jeffress Research Grants being announced here have been awarded in 2004.

The Jeffress Memorial Trust is administered by Bank of America. Additional information about the program of the Trust may be obtained by writing to: Richard B. Brandt, Ph.D., Advisor, Thomas F. and Kate Miller Jeffress Memorial Trust, Bank of America, Private Bank, P. 0. Box 26688, Richmond, VA 23261-6688. An unofficial website is listed under Grants and Awards, www.vacadsci.org/grants.htm.

Julio C. Alvarez. Virginia Commonwealth University. Development of Electrochemical Biosensors in Plastic Microfluidic Chips. $30,000. (one year).

Rebecca Ambers. Sweet Briar College. The Infleuence of Clay Mineralogy and Mineral Cements on Stream Channel Erodability. $30,000. (one year).

Joseph D. Ametepe. Hollins University. Studying and Using Discharges from a Novel High-Energy Ultraviolet Light Source for Destroying Viruses and Bacteria in Drinking Water. $30,000. (one year).

Mark Anderson. Virginia Polytechnic Institute and State University. Development and Characterization of a Multisensor Array for Biosensing. $30,000. (one year).

Craig Bayse, Old Dominion University. Understanding the Role of Se.. .N, 0 Interactions in the Activity of Selenoproteins and their Mimics: A Theoretical Study. $30,000. (one year).

Barney M. Bishop, George Mason University. Folding β-Defensins and Precursors of Peptides. $28,280. (one year).

Robert A. Bloodgood, University of Virginia School of Medicine. Calcium Regulation of Whole Cell Locomotion. $10,000. (one year renewal).

Bonnie L. Brown, Virginia Commonwealth University. Isolation and Analysis of Molecular Markers for Genome Mapping of Oysters. $10,000. (one year renewal).

Jan Chaloupka. The College of William and Mary. The Effect of the Longitudinal Electrical Field in an Intense Laser Pulse on the Double Ionization of Atoms. $30,000. (one year).

Stuart C. Clough, University of Richmond. The Preparation and Application of 5-chioro-5-aryl-2, 4-pentadienoates to the Regioselective Synthesis of Heterocycles and Carbocycles. $10,000. (one year renewal).

Randolph A. Coleman, College of William and Mary. Biochemical Studies of G-Protein Coupled Receptors via Stimulation and Modeling. $30,000. (one year).

Roland Cooper, Old Dominion University. Alkylation of Proteins by the Antimalarial Drug Artiminisin. $30,000. (one year).

Richard M. Costanzo, Virginia Commonwealth University. Recovery from Olfactory Nerve Injury. $30,000. (one year).

Gary G. Coté, Radford University. Regulation of Plant Crystal-Containing Idioblast Cells by Herbivory. $7,820. (one year renewal)

Brian Cusato, Sweet Briar College. The Pavlovian Conditioning on Sexual Behavior and Fertility in Female Japanese Quail *(Coturnix japonica)*. $10,000. (one year renewal).

Janet Chen Daniel, James Madison University. Identification of Amino Acid Sequence Motifs Involved in the Determination of Substrate Specificity of the STPI Hexose Transporter of *A rabidopsis thaliana.* $10,000. (one year renewal).

Jonathan Dattelbaum. University of Richmond. Genetically Engineered Protein Biosensors for Glutamate: An Important Human Neurotransmitter. $30,000. (one year).

Keith Davies, George Mason University. Transport of Diazeniumdiolates in Liposome Media. $25,000. (one year).

Swati P. Deb, Virginia Commonwealth University. Function and Dysfunction of the Human Oncoprotein MDM2. $30,000. (one year).

Antonio del Castillo, Virginia Commonwealth University. Role of Feto Protein Transcription Factor (FTF) in Bile Acid Synthesis. $10,000. (one year renewal).

Christopher Del Negro, The College of William and Mary. Do Pacemaker Neurons Generate the Rhythum for Breathing?. $10,000. (one year renewal).

James Eason, Washington and Lee University. The Mechanisms of Defibrillation During Acute Myocardial Ischema $10,000. (one year renewal).

Marcia B. France, Washington and Lee University. Chiral Schiff Base Complexes as Catalysts for Assemetric Cyclopropanation. $10,000. (one year renewal).

Mark L. Gabriele, James Madison University. Understanding Early Circuit Formation and the Spatial Arrangement of Ascending and Descending Projection Patterns in the Developing Auditory System Prior to the Onset of Hearing. $10,000. (one year renewal).

George W. Gilchrist, The College of William and Mary. The Genetic Architecture of Rapidly Evolving Traits in Invading Populations of *Drosophila suhobscura*. $10,000. (one year renewal).

Earl W. Godfrey, Eastern Virginia Medical School. Identification of Candidate Proteins for Polysynaptic Differentiation of the Neuromuscular Junction. $10,000. (one year renewal).

Emma Goldman, University of Richmond. Synthesis and Characterization of a Series of Dicopper Compounds for Use as Electro catalysts in the Reduction of Carbon Dioxide. $10,000. (one year renewal).

William M. Grogan, Virginia Commonwealth University/Medical College of Virginia. Characterization and Quantification of Post-Translationally Modified Cholesteryl Esterases in Biological Samples by Electrospray Tonization-Fourier Transformion Cyclotron resonance (ESI-FTICR) Mass Spectrometry. $10,000. (one year renewal).

Susan R. Halsell. James Madison University. Characterization of Mutations that Affect RhoA Signal Transduction During the Development of *Drosophila melanogaster*. $30,000. (one year).

Barbara Hargrave, Old Dominion University. Development of a Mouse Model to Investigate Gender Differences in the Susceptibility to Cardiovascular Disease. $9,920. (one year renewal).

Reid Harris, James Madison University. The Population Ecology of a Salamander Species in Relation to its Bacterial Symbiosis. $27,500. (one year).

James B. Herrick, James Madison University. Exogenous Isolation and Characterization of Antibiotic Resistance Plasmids from an Agriculturally-Impacted Stream. $10,000. (one year renewal).

Joel W. Hockensmith, University of Virginia Medical School. Inhibitors of DNA-Dependent ATP Hydrolytic Activity and Associated Functions. $10,000. (one year renewal).

Walter M. Holmes. Virginia Commonwealth University Health System. Molecular Basis for Themotoga Protein and RNA Heat Stability. $30,000. (one year).

Robert Humston, Virginia Military Institute. Reconstructing Movement Patterns of Smallmouth Bass *(Micropterus dolomieu)* from Elemental Chemistry of Otoliths. $30,000. (One year).

Scott Hyman, Sweet Briar College. A Galactic Center Variable and Transient Radio Source Monitoring Program. $10,000. (one year renewal).

Helen I'Anson, Washington and Lee University. Metabolic Regulation of the Onset of Puberty. $10,000. (one year renewal).

Jeffrey E. Janovetz, Sweet Briar College. The Functional Morphology of Feeding in Piranhas and Related Fishes. $30,000. (one year).

Kenneth W. Kambis, College of William and Mary. The Effects of Carbohydrate Ingestion Mood State During Endurance Work Performance at Moderate and High Altitude. $20,000. (one year).

Giti Khodaparast. Virginia Polytechnic Institute and State University. Tetrahertz Emission from Parabolic Semiconductor Heterostructures. $30,000. (one year).

Todd Kitten. Virginia Commonwealth University Health System. Systematic Mutagenesis of Surface Protein Genes in the Endocarditis Pathogen, *Streptococcus sanguis*. $30,000. (one year).

Brian M. Kelley, Bridgewater College. The Influence of Adolescent Nicotine Exposure on Adult Drug Sensitivity and Substance Abuse Risk. $10,000. (one year renewal)

Keith G. Kozminski. University of Virginia. Regulation of Polarized Morphogenesis Functional Analysis of Zds2p in *S. cerevisiae*. $22,500. (one year).

Rahul Kulkarni. Virginia Polytechnic Institute and State University. Computational Analysis of Bacterial Quorum-Sensing Networks. $27,000. (one year).

Lisa M. Landino, The College of William and Mary. Probing the Reactivity of the Sulfhydryl Groups of Microtubule Proteins. $10,000. (one year renewal).

David A. Lanning. Virginia Commonwealth University Health System. Homeobox Gene Expression in Fetal and Rabbit Wounds. $30,000. (one year).

Michael C. Leopold, University of Richmond. Biological Enhanced Metallic Nonoparticles: The Next Dimension of Protein Enhanced Monolayer Electrochemistry. $10,000. (one year renewal).

Nilanga Liyanage, University of Virginia. Construction of a Proto-Type Multi-Wire Proportional Chamber for Jefferson Lab. Engineering. $10,000. (one year renewal)

Dongmin Liu. Virginia Polytechnic Institute and State University. Molecular Mechanism of Dehydroepiandrosterone in Regulation of Angiogenesis. $30,000. (one year).

Rowan Lockwood, The College of William and Mary. Live-Dead Assemblage Comparisons in the Chesapeake Bay: Laying the Groundwork for Paleological Analyses of Holocene Benthic Molluscs. $10,000. (one year renewal).

Gyorgy Lonart, Eastern Virginia Medical School. Interaction of Phospho-RIM1a with the Release Machinery. $30,000. (one year).

Robin Looft-Wilson. The College of William and Mary. Vascular Cell-to-Cell Communication in Hyperhomocysteinemia. $30,000. (one year).

Michael Madigan, Virginia Polytechnic Institute and State University. Effects of Low Back Fatigue on Balance. $10,000. (one year renewal).

Irma Mazilu. Washington and Lee University. A Study of Some Non-Equilibrium Driven Models and Their Contribution to the Understanding of Molecular Motors. $30,000. (one year).

John Ross McClung, Virginia Commonwealth University. Extraocular Muscle Compartmentalization. $23,000. (one year).

Robert J. McKallip, Virginia Commonwealth University. The Effects of Cannabinoid Exposure on Tumor Growth and the Anti-Tumor Immune Response. $30,000. (one year).

W. Alex Meredith. Virginia Commonwealth University Health System. Effect of Measured Deafness in Cortical Sensory Processing. $30,000. (one year).

Jeffrey K. Nelson, The College of William and Mary. Studies of the Charge Asymmetry in Cosmic Ray Muons and Atmospheric Neutrino Interactions. $30,000. (one year).

Gregory M. Plunkett, Virginia Commonwealth University. Evolutionary Patterns in Plerandra Group of *Schefflera* (Araliaceae). $29,219. (one year).

Joseph H. Porter, Virginia Commonwealth University. Effects of Antipshchotic Drugs on Phencyclidine (PCD)-Induced Impairments in Reference and Working Memories in Mice. $10,000. (one year renewal).

Robyn A. Puffenbarger, Bridgewater College. Cannabinoid Receptor Expression in Macrophages. $10,000. (one year renewal).

Leonard Pysh, Roanoke College. SABRE and Root Cell Shapes in *Arabidopsis thaliana*. $29,000. (one year).

Jennifer Radkiewicz, Old Dominion University. An Investigation of 2-Aminoethoxydipphenylborate and Analogs as Store-Operated Calcium Entry Channel Inhibitors. $10,000. (one year renewal).

Gary Radice, University of Richmond. Origin and Specification of Lymphatic Heart Myoblasts. $25,000. (one year).

Shunlin Ren, Virginia Commonwealth University. Biochemical Study of Cholesterol Transporter in Bile Acid Synthesis. $10,000. (one year renewal).

Terrie K. Rife, James Madison University. Understanding Transcriptional Changes of Nitric Oxide Synthetase Tin Neurons Using a PC12 Cell Model. $10,000. (one year renewal).

Margaret Saha, The College of William and Mary. Novel Laser-Based Strategies for the Insertion of DNA into Cells of Living Organisms. $10,000. (one year renewal).

Vladimir Siderov. Virginia Commonwealth University Health Systeni. Active Delivery of Substrates by Ditopic Receptors. $30,000. (one year).

Kevin Simon, James Madison University. Interaction Among Organic Matter, Microtubule Films, and Animals in Cave Stream Food Webs. $30,000. (one year).

Caroline Smith, James Madison University. The Aeroacoustics of Turbulent Coanda Jets. $10,000. (one year renewal).

Christopher M. Stevenson and Derek Wheeler, Department of Historic Resources Commonwealth of Virginia. The Hydration Dating of Historic Soda-Lime Glass: A New Archeological Dating Method. $10,000. (one year renewal).

Kam Tang, Virginia Institute of Marine Science. Copepods as Microbial Hotspots in DMSP Dynamics: Effects of Host Feeding Activities on Attached DMSP-Consuming Bacteria. $10,000. (one year renewal).

John M. Warrick. University of Richmond. CREB-Binding Protein Modulation in a *Drosophila* Model of MJD and the Role of Chaperones. $29,000. (one year).

Raphael J. Witorsch, Virginia Commonwealth University. G-Screen Microassay for the Identification of Xenoglucocorticoids $10,000. (one year renewal).

Roshna Wunderlich, James Madison University. Biomechanics of Bipedal Locomotion in *Propithecus verreauxi.* $10,000. (one year renewal).

Grace A. Wyngaard, James Madison University. Variability in Chromatin as a Mechanism of Rapid Evolution. $22,500. (one year).

Ping Xu, Virginia Commonwealth University. Comparative Genome of Virulence Related Genes in Streptococcus. $30,000. (one year).

Henry M. Yochum, III, Sweet Briar College. Optical Spectroscopy of Defects in Undoped Yttrium Orthovanadate Crystals. $10,000. (one year renewal)

Chenming Zhang, Virginia Polytechnic Institute and State University. Effectiveness of Site Selection by Molecular Modeling for Site-Directed Protein Mutagenesis. $10,000. (one year renewal).

Quibing Zhou, Virginia Commonwealth University. D N A P r o m o t e d Intercalating/Alkylating Drugs. $10,000. (one year renewal).

Patty Zwollo, College of William and Mary. Developing Molecular Tools for the Analysis of Trout Humoral Immunity: Isolation of Gene Encoding Transcription Factors PAX-5 and Blimp-1 Monoclonal Antibody Production. $30,000. (one year).

MINUTES
COUNCIL MEETING
Friday, 5/26/06, 8 – 9:40 AM
Inn at Virginia Tech, Skelton Conference Center
Blacksburg VA

1. Minutes – Previous Meetings Agenda distributed but not minutes of prior meetings. Jerry Bass indicated detailed minutes should be circulated as official record and go into journal.VAS is required by law to archive minutes as a 501 c organization.

2. VJAS/VAS Report – Shelly Jobst
Not final numbers yet.
VAS: 70 early registrants
              11 late registrants
              20 late student registrants
              >40 onsite registrants
              65 tickets purchased prior to banquet. A few onsite.

VJAS: 643 student registrants (115 for Wed only)
              530 stay on campus (90 were chaperones)
              $19,877.75 revenue collected to pay expenses for VJAS.
              4-6 months to reconcile account.
              No medical emergencies; no room damage reported; students behaved well
              overall.

Jerry Bass complimented VT group for being so efficient and responsive. VT President (Dr. Charles W. Steger) also showed up, which is not common at other universities.

John Hess provided a listing of the local arrangements team at Virginia Tech, sources of administrative and financial support and the colleges at VT providing scholarships.

3. Section Reports – Councilors/Representatives
     Environmental Science – Michael Bass: small group but had 16-19 present.
     Chemistry – Jerry Bass: half lecture by Jim McGrath of VT, very prominent polymer chemist. Good attendance. Recommend this approach to other sections.
     Botany – Marion Lobstein: didn't have the numbers as in the past. Max of 35 attendees. Had a special presentation which was well attended. Jay Stipes of VT gave a campus tree walk which was wonderful.
     Biology with Microbiology and Molecular Biology – Carolyn Conway: New people participated. Microbiologists that attended mentioned overlap with the annual ASM meeting. But unfortunately, VAS can't change their date.
     Astronomy, Mathematics, Physics with Materials Science – Rae Carpenter: afternoon had 8 attendees. Elected a chair/vice chair from JMU students. These 2 also presented in the student competition and were the top 2. Hard to choose 1st place. Finally chose one to received $100 1st place award, and attendees wanted to/did donate

cash to give $50 to 2nd place.

Agriculture, Forestry and Aquaculture – David Crosby: 16 talks, 3 poster. 6-18 attendees.

Jerry Bass said good action at posters Thursday morning with students and faculty attending. We should look at ways to bring session rooms closer to poster area. David Crosby mentioned that it is necessary to get information to section secretaries earlier.

4. Business Report – Jerry Bass

Moved/seconded to reappoint Elsa Falls to the Trust Committee until 2009 (3 year appointment). Approved unanimously.

Combined financial report distributed. Finances are up to date except for one bill for ~$3k outstanding for VJAS program book. Large transfer ($46k) from Trust Fund explained: $12k for Flora Fund

$5k for non-endowed VJAS awards

$3k for scholarships @ institutions

$10k for Bethel scholarship

$25k for general operating expenses; convention services entail a higher cost. At VCU last time,costs not as high because Drs. Trani and Huff paid for a lot.

Should form a committee to look at finances for the future.

Ready to mail informal audit, charitable organization report through Commonwealth of Virginia. Filling out forms again for tax exempt status.

New memberships trickling in.

Looking to shifting annual meeting one day later. May increase students and faculty to attend. Have to check with availability at JMU for 2007.

Rae Carpenter asked why Fund for the Future wasn't included in distributed financial report because without it, do not have an accurate trail of making or losing money. Jerry to include.

No directory done for 2005/2006 but one is needed. Moved/seconded to create a 2006/2007 director. Approved unanimously. Lots of information needs to be collected. Wouldn't have all updates until August 2006. VJAS would be updated in July.

Moved/seconded for Bob Fisher to be reappointed to Research Committee. Approved unanimously.

Bob Fisher said some committees were active while others had members who don't even know they're on the committee and won't respond to Bob's emails.

Bob Fisher nominated VCU John Ryan for reelection to the Research Committee. In discussion, it was felt that the physical sciences might need better representation on the committee. R. Edward Barker (retired) from UVa Material Science was suggested to serve for 2006-2011 (5 year term). Each year has a new representative elected for the five member committee. Bob Fisher withdrew the nomination of John Ryan, and R. Edward Barker was approved.

5. CHANCO

Retreat: arrive for dinner on Fri, Sept 8. Ends Sunday, Sept 10, around 11am. No lunch so attendees can be on their way home.

Don Whitney to distribute an agenda for CHANCO soon.Contract issues. Jerry Bass suggested we discuss planning meetings further in advance. Should the cycle be 2 or

3 years for a university site? Technology issues: have computer/projection arranged ahead of time. JMU is not an issue. At VT, VJAS met in Squires Student Center which was not set up for projection like classrooms. Better to negotiate with university ahead of time.

6.   Idea Future Plans

Don Whitney suggested Powerpoint presentations on website with pictures, to stir membership with everyone contributing from their section or area. Perhaps make connection with deans of schools and presidents to distribute VAS info to departments/faculty.

It is a problem for membership to maintain contact/updated addresses. Is a membership survey needed?

7.   Miscellaneous

Trust Committee report distributed – Elsa Falls. Took over from Rae Carpenter who was chair for 16 years. Big shoes to fill. Great thanks to Rae for his many years of service, for continuity, and for continued help. Rosemary Barra joined the committee. They are meeting with Elsa's husband who is a financial advisor donating his time. Balance of 1,080,822; 1st quarter up 5.4% since 12/31/05.

Gerald Taylor moved to withdraw his name from consideration for VAS representative to the Board of SMV and nominated Jim O'Brien which must be approved by governor. Motioned/seconded and approved unanimously.

Rae Carpenter reported on SMV. With no state budget, state agencies have been preparing 2 budgets. Walter Witschey doing a great job to keep SMV solvent.   He wants to get a history started on SMV; Charlotte Webb who prepared VAS history might be available to do SMV so looking for someone to fill this role.

Susan Booth distributed some issues to discuss at CHANCO with respect to VJAS (Appendix 5). T-shirt selling was profitable. Two past VJAS officers (historian and president, Tristen Hayes & Kelly O'Brient) were elected as seniors in high school; they could be a connection to undergrads when they go to college (VCU). Will start generating a list of names/colleges attending to get this connection going.

Marion Lobstein distributed Flora pages. VAS contributed much, and she was very thankful. The investment has been well spend in illustrations (total 231). UVa Press will be the publisher; contract in process. There are 3800 species; over 1400 will be illustrated and smaller ones plated. By 2011/2012, it will be done. Book and DVD to be available. Wanting to improve website.

8.   Adjournment 9:40am EST

Virginia Academy of Sciences Leadership Retreat
CHANCO-on-the-James
September 8-9, 2006

MINUTES
Friday, September 8, 2006

1) **Don Whitney opened the evening discussion at 7:45pm**

Attendance:
Donald Whitney – President
Werner Wieland – President-Elect
Jennifer Wayne - Secretary
James Martin – Vice-President
Jerry Bass – Executive Officer
Michael Bass – Environment
John Hess - Archives
Carolyn Conway – Awards
Jim O'Brien – Fundraising/AAAS
Marion Lobstein – Virginia Flora
Ali Mohamed – Nominations & Elections
Lisa Martin – Administrative Assistant
Susan Booth – VJAS Director/Fundraising
Art Burke - Trust
Jerry Taylor – Constitution & By-Laws, VSRN

2) **Frequency of Hosting Institution:**

Current schedule: 2007 JMU
                           2008 Hampton (contract not yet signed though)
                           2009 (open)

2007 dates:	Wed May 23	Juniors arrive
	Thu May 24	VJAS
	Fri May 25	VAS
	Sat May 26	VAS Executive Committee/ Council meets

Dates chosen because of university academic schedule – when students leave from spring semester, commencement, cleaning of dorm rooms, before summer session begins, SOLs forVJAS.

Jerry Bass distributed recent meeting revenue summary:

YEAR	SITE	GROSS MEETING REVENUE
2006	VT	($30,000 estimated)
2005	JMU	$37,137.11

2004	VCU	$58,652.55
2003	UVa	$48
2002	Hampton	$52
2001	JMU	$27,147.51

Getting expensive even at colleges. The high revenue at VCU as VCU devoted resources so cost decreased & revenue increased. Hampton doesn't have a continuing education center that requires payment. Depending on site, VAS may be charged parking: $15/registrant at VT incorporated in per person fee; $8 per registrant at UVa.

Jerry Taylor reports that JMU would be happy to have it there every 2 years.

Feedback very positive from VJAS at JMU, VCU.

Mary Washington not ready to host, particularly with size of VJAS.

Perhaps revive University of Richmond as a site but need a new contact there.

Should mention scholarship connections and that VAS is a good recruity tool with VJAS. Art Burke suggested getting testimonials from the two VJAS participants who are now attending VCU because VJAS was held there.

Don Whitney expressed that Hampton University hasn't seen much return in terms of recruitment but has in visibility.

Jerry Bass suggested Longwood which has a scholarship and is trying to improve its reputation. Need a contact there with some clout.

Art Burke suggested looking retrospectively over the past decade or so to establish a selection process: 1) # new members after a conference; 2) how many participants from the hosting university community; 3) look at junior/senior registration numbers.

Academy has to have revenue to survive but main purpose is to serve.

Susan Booth reported that VCU, VT, UR, Lynchburg, Sweetbriar are new participants to VAST. The goal is to expose students to more universities but not as critical an element.

What locations are we not reaching out to for hosting the annual meeting? VJAS and judges love JMU, Hampton, Radford where rooms and food are centrally located; easier to get judges to come. At VT, UVa, things were too spread out. ODU wasn't too welcoming and wanted 30% of revenue, but they may have a change of focus. Most important issue for VJAS is judges from senior academy.

Jerry Taylor and others agreed that 3 years in advance was an appropriate timing to schedule sites or issues could change at site. Should consider VCU for 2009, JMU again in 2010. Jerry Bass to investigate potential of VCU for 2009.

Rosemary Barra, Susan Booth, and Bob Willis created a document detailing issues to negotiate with universities about needs of VJAS/VAS when generating a contract. Some factors to consider:

undergraduate participation is more than graduate students

good to have posters in one place, centrally located

allot more time to poster viewing/judging

increase financial incentives at VAS

perhaps combine registration with membership

3) Program Issues at the Annual Meeting:

Forensic Science or Nanotechnology as new sections was suggested. VCU has programs in these areas; VSU, Hampton are starting ones. They have been discussed before at prior retreats – not hard to start a new section but needs active officers. Often an offshoot of a growing section. Must have people to ask to be a section officer. May become official after one successful program at an annual meeting. Art Burke suggested symposium on the topic to get it started.

Marion Lobstein offered that symposia seem to attract new members. A possible idea would be to tie in the 400th anniversary of Jamestown. Susan Booth suggested Engineering Design & Technology could be a good symposia topic. Governor's schools insist applicants have participated in VJAS.

Are we meeting the needs of academy members? Industrial members have been lost. Jerry Bass offered that VAS receives more notice at small colleges/university in comparison to large research universities. Undergraduate research competition a great draw.

Ali Mohamed suggested a survey for membership expectations.

Susan Booth suggested to followup with VJAS members now at college/universities.

Get business leaders on board.

4) Adjourn at 9:55p

Virginia Academy of Sciences Leadership Retreat
CHANCO-on-the-James
September 8-9, 2006

MINUTES
Saturday, September 9, 2006

1) Don Whitney opened the morning retreat discussion at 9:15am
Attendance:
Donald Whitney – President
Werner Wieland – President-Elect
James Martin – Vice-President
Jennifer Wayne - Secretary
Jerry Bass – Executive Officer
Michael Bass – Environment
John Hess - Archives
Jim O'Brien – Fund raising/AAAS
Carolyn Conway – Awards
Marion Lobstein – Virginia Flora
Ali Mohamed – Nominations & Elections
Lisa Martin – Administrative Assistant
Susan Booth – VJAS Director/Fundraising
Art Burke – Trust
Jerry Taylor – Constitution & By-Laws, VSRN
Elsa Falls – Trust
David Knappenburger – VSRN

2) Approval of minutes from last 3 meetings: 11/20/05, 3/25/06, 5/26/06
Elsa suggested someone go through minutes in detail if they are to be published. Minor changes made to minutes. Moved/seconded/approved unanimously. Need to document that Bob Willis was nominated and approved as Fellow in Virginia Scientist issue and will go into Journal. Will be added to March minutes.

3) VSRN Report – David Knappenburger
The main mission is to connect to working teachers and then to students.
Website: new configuration created to meet state/federal guidelines/regulations for access. Incorporating statistics for number of hits. Should look at opening up site/database for students to connect to a researcher given teacher approval (student logon initiative). Twelve colleges/universities shown on site with links.
Working on a series of workshops for teachers, leading student research.
Membership list is being updated: 480 teachers, 187 scientists. In comparison, VAS membership is 2000.
$5000 has been allocated to VSRN but hasn't been depleted.
John Hess said many federal funding agencies look for K-12 initiatives so how to get the word out to universities that VSRN exists? Perhaps through the Sponsored

Programs offices or academy members who would disseminate information.

Art Burke suggested contacting the US Secretary of Education about VSRN for suggestions and make her aware of its existence.

Susan Booth said some Department of Education grants mention VAST involvement but no support letters exist.

4) Finance Report – Jerry Bass

Report distributed and comparison to prior year. Conclusion is that VAS is solvent. Out of line are VAS expenses but because program printing was entered in the wrong place. Income from meetings decreased so dependence on Trust funds is increasing. Audit/insurance fees increased. Dues/annual income should to go up in Fall as annual members renew and annual meeting finances are finalized. So the $11k deficit should turn positive.

Wants to reenact finance committee; Don Whitney to appoint a committee; followup by email. Perhaps Jerry Bass, Elsa, VAS treasurer, VJAS director would be appropriate members. Only difficulty is the conflict that VJAS director submits a budget to the committee for approval. Art Burke offered his time to the committee. John Hess's involvement may be solicited. A maximum of 5 was felt appropriate.

Jerry Taylor suggested decrease the number of journal issues/year to save on postage/printing costs. Three issues in 2005 cost $8500. Susan Booth said VJAS is doing an electronic journal as they couldn't afford hardcopy.

Nothing is published from Fall research meeting which cost $3900 in 2005. It is getting popular; some income is realized from $10 registration fee.

Jerry asked for budget requests before end of September from Susan Booth, Jim Martin, Ali Mohamed, Marion Lobstein, Jerry Taylor, Jim O'Brien.

5) Trust Report – Elsa Falls

Report distributed.

Trust committee (Elsa as chair, Rae Carpenter, Rosemary Barra, Jerry Taylor as ex-officio) has met two times since the VT meeting, once at VT and then again in August.

As of 9/9/06, $1,064,000. No longer have 9-10% drawdown from interest as investment returns are decreasing. Perhaps a 5% return can be realized.

One % automatically goes to the Fund for the Future. Seven % of all new monies goes to Fund for the Future which was done to insure monies available for funds that pay salaries.

All funds are American Funds. Pulled out of American Century because of fund duplications. Redistributed larger funds like VJAS into subfunds so ,all eggs were not in one basket. S&P used for comparison.

Jerry Bass transferred $4000 each of his years for VJAS loan from Trust. They borrowed $40k. This was started in 2003/2004 and continue 10 years.

Jim O'Brien said the Legacy Fund was zeroed out and put into Fund for the Future.

6) Awards – Carolyn Conway

Working on getting list of VAS 2006 awards to Office. Ali Mohamed has four applications for research grants which was sent in May with a July deadline. Most likely there will be four awards.

7) Virginia Scientists – Jim O'Brien

Most recent issue sent to Jim Martin, including editor position opening. Currently aiming for 3 issues/year.

Jim's assistant helped to get this issue together; she would be willing to do the next if paid. Jim's student would do the newsletter for $400/issue but this was not a popular option with the attendees. Jim to send a summary of his assistant's name/address/what she did to Don Whitney who will make a request to Jerry Bass to pay her $400 for past work.

Susan Booth mentioned that VJAS gives a $500 stipend to each of 3 students for VAST and one stipend for the newsletter.

Prior expenses for newsletter: $2600 in 2004; $1900 in 2005; $2700 in 2006 budgeted but not used yet.

The question was raised whether the newsletter has outlived its usefulness. John Hess pointed out that no professional organization doesn't have a newsletter.

Don Whitney charges the Publications committee to find an editor/overseer.

Everyone expressed appreciation to Jim O'Brien for all he has done with the newsletter.

8)   Next Meetings

Next Council meeting set for Sunday, November 19[th]at the Science Museum of Virginia, 9:30am.

Next Research meeting set for Saturday, October 21[st]at Science Museum of Virginia; it should be made an annual October meeting on VAS website.

BREAK FOR LUNCH 12:30pm; RESUMED AT 1:40pm

9)   2007 Annual Meeting at JMU

Dinner with Scientists will be Thursday evening for VJAS.

Where will the VAS poster facility be? Last time it was in the hallway. Discussed was whether to include the length of time to visit posters in the program.

President to choose Negus lecturer and can offer an honorarium of $500.

VJAS has two speakers – one from the host institution and a second. (Wednesday/Thursday evenings).

VAS Vice President is in charge of the whole program including special symposia. One topic previously offered was on Evolution vs Intelligent Design. Jim O'Brien offered Francis Collins; his book ,Can You Believe in God and Evolution? Art Burke offered Astronomy and Pluto as a symposia topic. Jerry Taylor offered the woman at Harvard who was in VJAS 40 years ago.

Have to insure an audience is present in VAS sections for VJAS presentations.

Statistics section had a big group in 2006 while Aerospace section didn't meet. Neither had information in the 2006 program however.

Jerry Taylor asked that if there is to be a reserved table for the banquet at VAS, make sure the seats are filled. Host institution's administration should be acknowledged for their support at the banquet.

10) Future Issues – Jim O'Brien
Membership:

VAS brochure distributed. It has been sent to faculty in community colleges within a 50mile radius of host institution with a letter in the past. Will do so again, around JMU.

Art Burke suggested a one year membership (perhaps with restrictions) be offered to all new faculty members. Jerry Bass suggested to target middle universities (such as CNU, Longwood).

Jerry Taylor suggested that VAS write a letter to the University President and ask for names/addresses of new faculty, and then VAS will put a link for the university on the VSRN website.

Marion Lobstein suggested to target the VCCS meeting, 10/11, in Virginia Beach. Community colleges are growing in science/math education. They have displays as well.

To bring in new people to VAS and its sections, sections should get new faculty into small roles such as session chair or create group of presentations, then into officer. Other:

Lisa Martin mentioned that numerous students and others present without being members of VAS despite the, rule. Income from student membership is only $1500 so VAS is losing money on them because they get mailings which are typically returned because students move. And VAS pays for the return postage as well.

Jennifer Wayne suggested to have nonmember and member registration fees different and drop the requirement that presenters must be members. It was motioned/seconded to remove the requirement that presenters must be members; one author must be a member; the presenter must register to present – unanimous. This issue to be discussed again at the November meeting.

Susan Booth mentioned the 5k Run/Walk will be held Saturday September 23 in Pony Pasture Farms. Proceeds to go to Phil Robinson Research Fund.

Although typically done biannually, there was a desire to schedule the next retreat in September 2007 at Chanco.

11) Adjourn at 3:30pm.   Group photograph taken.

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Three complete copies of each manuscript and figures are required. It is also required that authors include a diskette in PC compatible format containing a text file (ASCII or acceptable word processing file) of the manuscript. Original figures need not be sent at this time. Authors should submit names of three potential reviewers. All manuscripts must be double-spaced. **Do not** use special effects such as bold or large print.

The title, author's name, affiliation, and address should be placed on a cover page. An abstract (not to exceed 200 words) summarizing the text, particularly the results and conclusions, is required. The text should follow the general format used by professional journals in the author's discipline and the Virginia Journal of Science has an on-line style manual. Literature cited in the text should follow the name-year format: (McCaffrey and Dueser, 1990) or (Williams et al., 1990). In the Literature Cited section at the end of the article, each reference should include the full name of the author(s), year, title of article, title of journal (using standard abbreviations), volume number and first and last page of the article. For a book, include author(s), year, title, pages or number of pages, publisher and city of publication. Examples:

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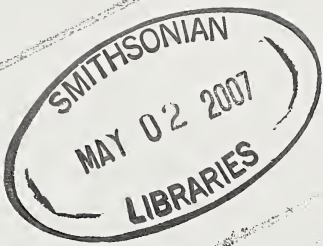
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Distribution and Status of the Southern Bog Lemming, *Synaptomys cooperi*, in Southeastern Virginia

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ABSTRACT

The Dismal Swamp subspecies of the southern bog lemming, *Synaptomys cooperi helaletes,* was named based on specimens collected during the 1895-1898 biological surveys conducted in the Dismal Swamp by the US Department of Agriculture. Unknown in the 20th Century until re-discovered in 1980, this small boreal rodent was believed to be restricted to the Great Dismal Swamp of Virginia and North Carolina where the cool damp conditions had permitted it to survive during the Holocene. However, field studies conducted since 1980 have revealed southern bog lemmings to be widespread throughout southeastern Virginia, with populations encompassing an area of more than 3300 km^2, including the cities of Virginia Beach, Chesapeake, and Suffolk, and Isle of Wight County. Lemmings were present on 38 of 165 (23%) pitfall-trapping sites; their frequency was much greater in prime habitats dominated by grasses and sedges on damp organic soils. Thus, southern bog lemmings are distributed widely in southeastern Virginia and, where present, they often are among the most numerous species of small mammal.

INTRODUCTION

The southern bog lemming, *Synaptomys cooperi*, distributed from Kansas and Nebraska northward through Minnesota and Manitoba, eastward through Canada, and southward into the Appalachian Mountains of North Carolina and Tennessee (Hall 1981), is one of the most enigmatic small mammals in North America. In some Midwestern states, highly trappable and high-density populations coexist with prairie voles in mesic or xeric grassland habitats (Kansas: Gaines et al. 1977; Illinois: Beasley and Getz 1986; Indiana: Krebs et al. 1969). In other permanently wet sites where herbivorous potential competitors often are absent, however, southern bog lemmings are difficult to trap. For example, isolated relic populations associated with permanently flowing springs (now incorporated into state-run fish hatcheries) are known from Meade County in southwestern Kansas and Dundy County in southwestern Nebraska. Other relic populations are believed to be restricted to the Pine Barrens of southern New Jersey and to the Dismal Swamp of southeastern Virginia and adjacent North Carolina.

Thus, populations of this small stocky rodent with short tail and tiny ears are highly patchy in both space and time. For example, in Douglas County in eastern Kansas, where generations of mammalogists have been trained at the University of Kansas since the 1920s, grassland populations existed for about four years starting in the middle 1920s (Lindale 1927, Burt 1928), then disappeared, reappeared in the middle 1940s, disappeared, and then reappeared in the mid-1960s, since when they have persisted (Rose et al. 1977, Norman A. Slade, University of Kansas, pers. comm., October 2005). Understanding its spatial distribution is made difficult because

Synaptomys cooperi often is reluctant to enter live traps. For example, Connor (1959) caught only 38 bog lemmings during four years of study in the swampy habitats of the New Jersey Pine Barrens. By contrast, other populations are readily trappable. Hundreds of *S. cooperi* were routinely trapped in two different kinds of live traps (Rose et al. 1977) in damp and dry oldfields in eastern Kansas, where they reached densities of 42-65 per hectare (Gaines et al. 1977, Gaines et al. 1979).

Clearly the name "bog lemming" is misleading because *Synaptomys* is not restricted to bogs or even to damp places. *Synaptomys* has been reported from areas of woody vegetation (Hamilton 1941, Coventry 1942, Connor 1959), moist grassy areas (Howell 1927, Stewart 1943, Smyth 1946, Burt 1928, Getz 1961), and from dry, south-facing grassy fields, such as in eastern Kansas (Gaines et al. 1977, Rose et al. 1977, Gaines et al. 1979).

First described in 1858 from specimens taken near Jackson, New Hampshire (Hall 1981), the generic name was given because Baird believed it to be a link (= *synapse*) between the lemmings (*Lemmus*) and the true mice (= *mys*). In 1895, investigators from the US Biological Surveys, led by A. K. Fisher, collected southern bog lemmings from cane brakes near Lake Drummond in Virginia's Dismal Swamp which Merriam (1896) described as a new species, *Synaptomys helaletes*. However, in his revision of the genus, Howell (1927) demoted the taxon to a subspecies, *S. cooperi helaletes,* a decision accepted by Wetzel (1955) in his taxonomic study of *S. cooperi.* More recently, Wilson and Ruff (1999) recognize seven subspecies, including the isolated forms in Kansas, Nebraska, and the Dismal Swamp region of Virginia and North Carolina.

Fisher collected other southern bog lemmings from the Dismal Swamp as late as 1898, but none was taken thereafter, despite the efforts of several investigators, including Charles O. Handley, Jr., Smithsonian Curator of Mammals, who trapped some of Fisher's sites in 1953, and in other years and places, all without success. Handley (1979) and others (Meanley 1973, Taylor 1974) speculated that since no specimens had been collected since 1898, the Dismal Swamp subspecies might be extinct. However, Rose (1981), using pitfall traps placed under powerlines in the northwest corner of the Great Dismal Swamp National Wildlife Refuge (GDSNWR), caught 13 specimens from three locations in 1980, laying to rest doubts about its existence.

During the 1980s and early 1990s, my students and I conducted survey trapping at over 100 sites throughout southeastern Virginia for the Dismal Swamp southeastern shrew, *Sorex longirostris fisheri,* then a federally listed mammal; the southern bog lemmings reported here were taken in those same collections. These studies have revealed the Dismal Swamp subspecies, *Synaptomys cooperi helaletes,* to be widespread in appropriate habitats throughout southeastern Virginia, with populations extending west of the Dismal Swamp at least through Isle of Wight County.

METHODS
Both live and pitfall traps were used in our studies, with the latter being used more extensively. Systematic live trapping was conducted in the open habitats under a 40-m wide powerline in the northwestern corner of the GDSNWR (Stankavich 1984). Fitch live traps (Rose 1973), set at 7.6-m intervals in two rectangular grids (0.38 and 0.40 ha), were tended for two days every two weeks from October 1980 to February 1982.

Other live trapping in the following two decades, conducted throughout the region in a range of habitats, has yielded only one other *Synaptomys* with live traps, except for an (unpublished) study conducted by L. J. Ford in Suffolk during 1987-1988.

Most information on distribution and relative abundance comes from pitfall traps set on 0.25-ha grids in a range of habitats in southeastern Virginia (Rose et al. 1990). Placed at 12.5-m intervals on a 5 X 5 grid, each pitfall trap was a #10 tin can placed in the ground flush with the surface and partly filled with water. Earlier studies (e.g., French 1980) had shown that southeastern shrews (and to a lesser extent, southern bog lemmings) are rarely taken in live or snap traps, necessitating the use of pitfall traps to collect distribution and status information on these species. In the initial study, funded by the Office of Endangered Species (Rose 1983, Everton 1985), 37 pitfall grids were set in a range of habitats centering on the GDSNWR. A later study (Padgett 1991), funded by the Virginia Department of Game and Inland Fisheries, added 29 grids, mostly placed at greater distances from the GDSNWR in an effort to learn the geographic extent of distribution of the Dismal Swamp southeastern shrew. Another 85 pitfall grids were set at a variety of sites in the region in surveys conducted between 1986 and 1995. Finally, current information on the western limit of distribution comes from a study conducted in 1992 on 14 grids set in the open habitats under powerlines in Isle of Wight County (Rose 2005).

Specimens collected in pitfall traps were returned to the lab, measured, weighed and evaluated for reproductive condition, and then saved (mostly as skull and skeleton). Most of these specimens now are in the collections of the Smithsonian Institution, with a few remaining in the teaching collection at Old Dominion University. Collectively, these surveys provide information on the habitats and extent of distribution of southern bog lemmings in southeastern Virginia.

RESULTS

Live trapping

Biweekly trapping for 17 months on the two live trap grids in the GDSNWR yielded 13 bog lemmings, two on Grid 1 and 11 on Grid 2 (Stankavich 1984). On Grid 2, none was caught until the 10th month, and then all were captured within a period of a few weeks. However, bog lemmings were known to be present from the start because they produce distinctive bright green bullet-shaped fecal pellets, plus they strip and eat the green outer covering from the softrush, *Juncus effusus,* leaving behind the spaghetti-like bits of pith.

Ford's year-long mark-and-release study was conducted on a large study grid in a regenerating clearcut near the intersection of Desert and Clay Hill Roads in Suffolk, on a site close to the GDSNWR. She caught several dozen each of bog lemmings and woodland voles (*Microtus pinetorum*) using modified Fitch live traps (Rose, 1994). For unknown reasons, the southern bog lemmings on this site were much more prone to entering live traps than the same species had been in Stankavich's (1984) study. The only other *Synaptomys* taken in live traps was an adult female collected early in 1999 in early successional habitat in a wetland bank now reverting to Dismal Swamp vegetation in southern Chesapeake.
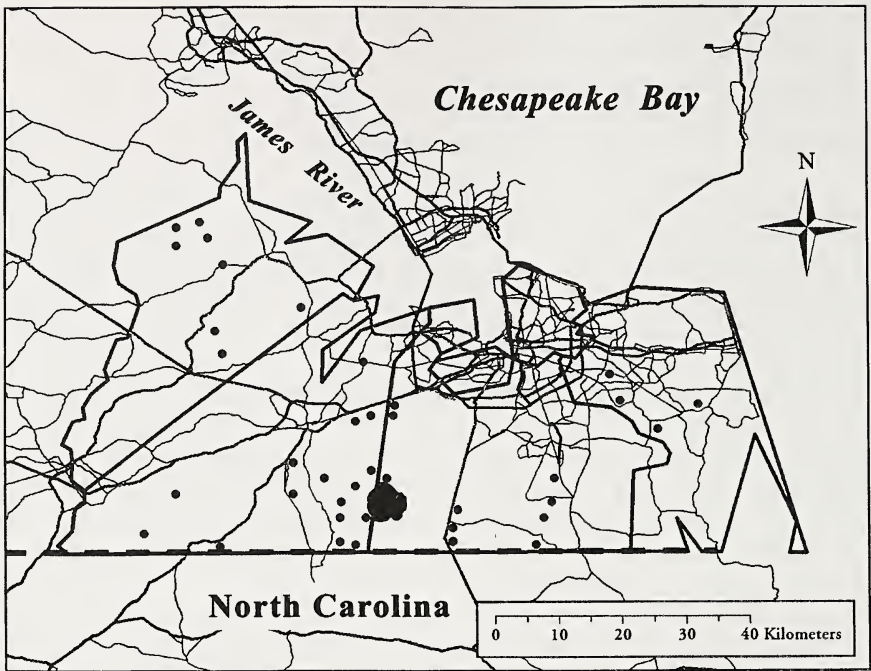
FIGURE 1. Map of southeastern Virginia showing the 38 locations in which southern bog lemmings were found in field studies conducted in the region. Starting from the left, there were 8 sites in Isle of Wight County, 16 in the City of Suffolk, 10 in the City of Chesapeake, and 4 in the City of Virginia Beach. Nine of the sites in Suffolk and 6 from Chesapeake were Great Dismal Swamp, mostly in the Great Dismal Swamp National Wildlife Refuge.

Pitfall trapping

Southern bog lemmings have been collected from 38 sites throughout the southeastern Virginia region (Figure 1). Many are from the GDSNWR and its margins, the area of most intensive study, but populations of the species were scattered over the entire region, from West Neck Creek, Farrell Parkway, and Gum Swamp in Virginia Beach, to the Naval Security Group-Northwest site, near Route 17, and the Hickory region in Chesapeake, to several locations in eastern and southwestern Suffolk, and eight localities in Isle of Wight County.

The best information on the composition of the small mammal communities of which *Synaptomys* is a part comes from Rose (1983), who found bog lemmings on 17 of 37 sites in and near the GDSNWR. When present, southern bog lemmings constituted 11.8 to 51.4 percent of animals on these 17 grids (Table 1). On sites with bog lemmings, they comprised an average of 25.3 percent of total captures. Similar results were seen in Isle of Wight County (Table 2), with bog lemmings being present on 8 of 14 grids, and comprising 17.1 percent of captures on grids with *Synaptomys*. Thus, when present, southern bog lemmings comprise a substantial proportion of the small mammal community.

Information on the small mammals associated with *Synaptomys* is presented in the bottom rows of Tables 1 and 2. *Sorex longirostris* was the most frequent associate (n

TABLE 1. Results of pitfall trapping on seventeen 0.25 ha grids with southern bog lemmings, set in and near the Great Dismal Swamp National Wildlife Refuge in Suffolk, Virginia (Rose, 1983). The mnemonics refer to the species names: Sc, southern bog lemming, *Synaptomys cooperi;* Sl, southeastern shrew, *Sorex longirostris;* Bl, short-tailed shrew, *Blarina brevicauda and B. carolinensis;* Cp, least shrew, *Cryptotis parva;* Mpe, meadow vole, *Microtus pennsylvanicus;* Pl, white-footed mouse, *Peromyscus leucopus;* Mm, house mouse, *Mus musculus;* Mpi, pine or woodland vole, *Microtus pinetorum;* On, golden mouse, *Ochrotomys nuttalli;* Op, marsh rice rat, *Oryzomys palustris.* "Associates" refers to the number of grids (out of 17 with Sc) that the species in that column was associated with. Thus, Sl was present on 15 of 17 grids with Sc.

Grid	Sc	Sl	Bl	Rh	Cp	Mpe	Pl	Mm	Mpi	On	Op	Totals
2	2	8	5									15
3	4	3	9	1			1					18
6	2	3	2									7
8	2		2	8	4		1					17
9	6	12	2	6	2		1	2	2			33
10	14	7	7	1								29
11	11	21	4							1		37
12	5	1		11	6		4			1		28
13	6	2	1	2			1	1	1		1	15
14	18	10		1	4		1		1			35
19	3			4	6	1	2	1				17
25	5	9	10	2						2		28
28	3	3	1	1	9		1					18
30	6	14	1	4			2		2			29
31	4	2		3	5		1					15
34	5	8	18	1	1				3			36
37	6	11	8			1						26
Totals	102	114	70	45	37	2	15	4	9	4	1	403
Associates	(17)	15	13	13	8	2	10	3	5	3	1	

= 15 of 17 grids) in Table 1 (Dismal Swamp and vicinity) but for the mostly drier sites in Isle of Wight County (Table 2), it was among the least common (n = 3 of 8 grids). *Reithrodontomys* was a common associate at both locations (15, 7); by contrast, *Cryptotis* was always present with *Synaptomys* in Isle of Wight County but these two species were found together on slightly less than half (8/17) of grids in the Dismal Swamp vicinity. Perhaps the most relevant associate because of its alleged competition with *Synaptomys* (Linzey 1984), *Microtus pennsylvanicus* (meadow vole) was found with *Synaptomys* on only 2 of 17 grids in the Dismal Swamp and on 3 of 8 grids in Isle of Wight County. In all instances, only one or two meadow voles were taken on grids also yielding *Synaptomys.* The mean number of associated small mammals in the varied habitats of the Dismal Swamp region was 11.8, compared to 12.1 small mammals in the open habitats under powerlines in Isle of Wight County.

Reproduction and body size

Sexual maturity is attained early in southern bog lemmings, in females sometimes before they are weaned. Except for one female, the nine pregnant *Synaptomys* in this study weighed 30 g or more (exclusive of their pregnant uteri), indicating that they

TABLE 2. Results of pitfall trapping on eight 0.25 ha grids with southern bog lemmings, set in locations throughout Isle of Wight County, Virginia (Rose, 2005). The mnemonics for the species names are defined in the legend to Table 1. "Associates" refers to the number of grids (out of 8 grids with *Synaptomys*) that the species in that column was associated with *Synaptomys*.

Grid	Sc	Sl	Bl	Rh	Cp	Mpe	Mpi	Totals
1	4		3	4	2		13	
2	2	2	2	2	10			18
3	4	3		16	6			29
4	1		2	3	3			9
5	1			4	5	2		12
6	1			3	5			9
7	1		2		4	1		8
8	6	1		3	6	2	1	19
Totals	20	6	9	35	41	5	1	117
Associates	(8)	3	4	7	8	3	1	

likely were mated after reaching 20 g. The exception was a 21-g female collected on February 25 with one embryo in each uterine horn. Litter sizes (embryo counts at necropsy) were either two or three, for a mean litter size of 2.56. However, counts of placental scars (indicating earlier litters) of four (from a 29-g female in late December), five (n = 3, all weighing 31-35 g), and six (from a 29-g female in late November) were also recorded. These placental scars were similar in color and size, more likely indicating one rather than two previous litters. Together these results indicate that females in this population can breed at low body weights and have litters of moderate size; both attributes are typical of the reproductive biology of microtine rodents.

Pregnant females were recorded for the months of November, December, and January to June. The appearance of juvenile animals (< 20 g) in the population during these months confirms this pattern of breeding throughout the winter months and into the early summer.

Male reproductive competency was assessed by the presence in convolutions in the cauda epididymis of the testis. Although the pattern of a November-to-June breeding season is less clear for males than for females, the absence of epididymal convolutions from July-September indicated that breeding was suspended during the hottest months of summer for males. Thus, in eastern Virginia, the breeding season of *Synaptomys* begins in late autumn (November) and extends into early summer (June).

The analysis of body size of a population or subspecies requires identification of adult animals in order to reduce the variation when juveniles and sub-adults are included. Adulthood can be identified empirically by the presence of embryos, sperm in testicular tubules, or by certain cranial features, the latter not considered here. In many mammals, adults can be defined by creating age classes based on tooth wear, but this method is not applicable to *Synaptomys* because all microtine rodents have ever-growing (open-rooted) teeth. Because I found only nine pregnant females and many more fertile males (many animals collected in warm months could not be accurately assessed for reproductive features), I cannot make a meaningful statistical analysis of

TABLE 3. Body dimensions for *Synaptomys* from the cities of Virginia Beach, Chesapeake, and Suffolk (combined) and from Isle of Wight County, Virginia. The asterisk (*) indicates significant differences in that body dimension compared to the other sex from that sample.

	Cities		Isle of Wight County	
	Males	Females	Males	Females
Sample size	65	51	13	7
Total length (mm)	118.71	117.63	118.54	128.86*
SE mean	1.47	1.58	2.44	4.72
Min-max values	83-143	80-151	102-129	117-151
Tail length (mm)	18.95	18.02	20.69	23.00
SE mean	0.34	0.61	0.86	2.90
Min-max values	12-25	7-23	15-26	18-23
Weight (g)	29.71*	27.34	27.96	32.17
SE mean	0.98	1.06	2.09	3.79
Min-max values	10-45	11-47.4	14.63-41.63	24.05-47.36

only adults. However, I can assume that males and females of all ages have equal probability of being caught in unbaited pitfall traps, and thus I believe these 78 males and 58 females (Table 3) are random samples of their sexes. When specimens from all four geographic areas were combined, the means of all males from Table 3 were 118.68 mm total length and 29.42 g, and those of females were 118.98 mm and 27.92 g. No dimorphism was detected for either body length ($t = 0.15$, $P > 0.05$) or body mass ($t = 1.09$, $P > 0.2$).

Habitat associations

The study grids with *Synaptomys* were dominated by grasses and sedges, often liberally sprinkled with seedlings of sweet gum (*Liquidambar styraciflua*) and red maple (*Acer rubrum*) and such shrubs as sweet pepperbush (*Clethra alnifolia*) and groundsel (*Baccharis halimifolia*). This vegetation is typical of regenerating sites in the region, such as those found after the clearcutting of plantations of loblolly pines (*Pinus taeda*) or sites under powerline rights-of-way which get mowed every 3-5 years. Monocots are essential for *Synaptomys* but the other vegetation does not seem to be so important. *Synaptomys* was present in some young pine plantations, but only in those with grasses. Several sites with *Synaptomys* were naturally regenerating recent clearcuts of pine trees, now with diverse vegetation including seedling volunteer trees, vines, shrubs, and the requisite grasses and sedges. Grass-dominated marshes, such as the 'remnant marsh' in the southern section of the GDSNWR (which had been burned and grazed by generations of farmers before this land became part of the refuge) and a similar grassy site near Driver (in rural Suffolk) that also appeared to have been maintained by burning or grazing, were most predictable in yielding southern bog lemmings. The presence of American cane (*Arundinaria gigantea*) also is a good predictor of the presence of southern bog lemmings, especially if the 3-4 cm cuttings of cane made by feeding *Synaptomys* are detected before setting the pitfall traps.

DISCUSSION

Live trapping

As with some other populations, southern bog lemmings from eastern Virginia are reluctant to enter live traps, as shown by their absence until the 10th month of biweekly trapping on Stankavich's Grid 2 and the capture of only one other *Synaptomys* in many years of survey trapping in the region. However, Ford (unpublished) caught several dozen *Synaptomys* on a young regenerating forest site where it was a co-dominant with *Microtus pinetorum*, a most unlikely pairing of herbivorous mammals. By contrast, Fitch live traps, also used in Rose et al. (1977), caught >200 *Synaptomys* in eastern Kansas. Gaines et al. (1977) used Longworth traps to catch hundreds of *Synaptomys*, also over a three-year period. Although the trapping effort was not comparable in these two studies, Longworth traps probably are superior in catching southern bog lemmings from oldfields in eastern Kansas. Handley (1979) used snap traps, and perhaps Sherman live traps, in his futile attempts to locate *Synaptomys* in the Dismal Swamp region. J. F. Merritt (Illinois Natural History Survey, pers. comm., October 2005) also failed to catch *Synaptomys* with Sherman traps in his field work in eastern Virginia from 1976-1979.

Pitfall trapping

Pitfall traps provided much more information than live traps on the presence and relative abundance of southern bog lemmings in the region. Nearly half of 0.25 ha study grids in and near the GDSNWR yielded *Synaptomys* (Table 1), and slightly more than half of 14 study grids in Isle of Wight also had southern bog lemmings (Table 2). Overall, 23 percent (38) of the 165 study grids yielded *Synaptomys* (Figure 1), and when they were present, southern bog lemmings constituted about 20 percent of captures. Thus, although patchy in distribution, southern bog lemmings can be numerous when present. If the term 'rare' is to be applied to this mammal, patchy distribution rather than number of individuals in the population must be the primary criterion.

Reproduction and body size

Embryo counts (= litter size) were either two or three for this study but some females had 4, 5, or 6 placental scars of similar age, indicating that some larger litters were achieved in this population. The range of litter sizes for the species is one to six (Linzey, 1983).

The breeding season began in late autumn (November) and continued into early summer (June); uterine embryos were recorded during every month during this period. Breeding was suspended in the hottest months of summer, and did not resume until the cooling effects of late autumn were present. This pattern of suspended breeding during the hottest months also was seen in Kansas populations of prairie voles, *Microtus ochrogaster* (Rose and Gaines, 1978). The very adaptations (short ears and tails, chunky bodies, and thick fur) that make microtine rodents suited for conserving heat in the winter make it difficult for them to dump heat in the summer months. Thus, microtine rodents must become highly nocturnal during the summer months in order to avoid the heat, and this change in feeding schedule may impinge on their ability to reproduce during the hottest months.

Furthermore, finding the resources to sustain breeding in the winter months is not a problem in the southern limits of distribution, because winter temperatures in eastern Virginia are like those of autumn in the northern states or provinces. The mean high temperature for the coldest month, January, is 9° C, and green grasses and sedges are present and growing year-round. Furthermore, microtine rodents are able to extract energy even from standing dead vegetation, relying on microbial fermentation and, in the case of *Synaptomys,* a massive spiral-shaped caecum which slows passage of food through the gut and further facilitates fermentation. Microtine rodents also consume their own soft moist fecal pellets (a behavior called coprophagy), extracting additional energy and nutrients as a result.

The greatest body weight of the 136 animals examined for body dimensions (Table 3) was 45 g for males and 47 g for females. However, the mean body lengths and masses of each sex were similar and less than 120 mm and 30 g, respectively. Because the samples of the sexes included juveniles and sub-adults as well as adults, sexual size dimorphism cannot be categorically demonstrated but is suggested by an analysis of all males and females. Neither Wetzel (all subspecies: 1955) nor Linzey (1983), for *Synaptomys cooperi stonei,* found sexual dimorphism. However, the body dimensions of *Synaptomys cooperi helaletes* from southeastern Virginia are considerably smaller than those of *S. c. gossii* from eastern Kansas, where Danielson and Gaines (1987a) reported males to average 39.1 g and females 37.1 g.

Habitat associations

Southern bog lemmings were present in 23 percent of sites that were trapped using pitfalls in this study. Originally the focus of study was the GDSNWR and its perimeter; later studies searched more widely for populations, and eventually populations were found in 8 of 14 sites in Isle of Wight County, well west of Dismal Swamp habitat type. Dense covering vegetation of grasses and sedges provided the most reliable clues that *Synaptomys* might be present. American cane was another useful predictor of its presence, especially if damp and peaty soil conditions prevailed. Everton (1985), using principal components analysis to examine the relationship between the presence of small mammals and 13 habitat variables, found *Synaptomys* to be associated with both short-tailed and southeastern shrews in habitats with structural diversity provided by shrubs, but also having substantial grassy and litter layers.

Although moist conditions and peaty soils often seemed to be predictors of the presence of *Synaptomys* in the Dismal Swamp, these habitat features seemed less important in Isle of Wight County, where most sections of almost all sites were considered uplands with dry mineral soils. There southern bog lemmings were often found in cane patches and also in small swales dominated by sedges and softrushes.

Although Rose and Spevak (1978) report behavioral dominance of prairie voles over bog lemmings in a laboratory study, Danielson and Gaines (1987b) found little evidence for mutual avoidance in the field.

By contrast, Linzey (1984) presents evidence, based on patterns of co-occurrence in marginal habitat and on removal experiments, that *Synaptomys cooperi stonei* competes for space, usually unsuccessfully, with *Microtus pennsylvanicus* near Blacksburg, in montane western Virginia. My results tend to support her contention (Tables 1 and 2). In the Dismal Swamp, both species were found together on only 2

of 37 grids, *Synaptomys* was found alone on 15 grids (mean of 5.8 lemmings/grid), *M. pennsylvanicus* was alone on 10 grids (mean of 5.4 voles/grid), and neither species was present on the other 10 grids (Rose 1983).   On the two grids with both species, there was a single meadow vole on each, compared to 3 and 6 southern bog lemmings. Thus, the avoidance was not complete, but on the two grids with both species, only a single meadow vole was present.   In Isle of Wight County, the pattern is less clear because both species were found together on 3 of 14 grids, *Synaptomys* was found alone on 5 grids (mean of 2.4 lemmings/grid), *M. pennsylvanicus* was alone on 4 grids (mean of 3.0 voles/grid), and neither species was present on the other 2 grids. Two of the 3 grids with both species had one or two of each species; the other grid had 6 southern bog lemmings and 2 meadow voles. I interpret these results to mean that the powerline rights of way in Isle of Wight County were marginal habitat for both species. Linzey and Cranford (1984) also found habitat differences between the two species near Blacksburg.

Geographic distribution in the region

In all, *Synaptomys cooperi* was found in 38 (23.0%) of 165 pitfall-trapping sites spread over an area (Figure 1) encompassing the cities of Virginia Beach (formerly Princess Anne County), Chesapeake (formerly Norfolk County), Suffolk (formerly Nansemond County), and Isle of Wight County.   The total area of these three municipalities and one county is 3,380 km^2, or 1305 mi^2. These 165 sites included many small patches (often surrounded by farm fields or development) as well as forested sites, where bog lemmings are not likely to be present.   Thus, for prime habitats, with dense covering vegetation of grasses and sedges and damp organic soils, the likelihood of the presence of *Synaptomys* probably approaches 50 percent in this region.

Conservation and management of Synaptomys in eastern Virginia

At present, *Synaptomys cooperi helaletes* is a taxon of Tier IV Greatest Conservation Need status in Virginia (VDGIF: Comprehensive Wildlife Conservation Strategy, 2005), primarily because its distribution is believed to be limited to a small area of the state, its populations are patchily distributed, and its prime habitats are rapidly being lost to development in eastern Virginia. Furthermore, the species remains difficult to assess for population status because it is predictably resistant to being taken with live or snap traps, the usual methods for surveying small mammals.   However, the results of my study, conducted primarily with pitfall traps, revealed *S. c. helaletes* to be more widely distributed in Virginia than previously believed and, where present, its numbers often are substantial, comprising about one-fifth of small mammal captures. Rather than being restricted to the Dismal Swamp (for which the GDSNWR is now the core area) as previously believed, southern bog lemmings were found in 38 locations across three cities and one county, with a total area of 3,380 km^2.

This pattern of distribution well beyond the forested swamps such as the Dismal Swamp also has been observed in North Carolina, based on 4 specimens collected over a large area (Clark et al. 1993, Webster et al. 1992).   Thus, populations of *Synaptomys cooperi helaletes* in eastern Virginia, and perhaps in eastern North Carolina, are doing moderately well, existing far beyond the cool moist swamps that still may be their refugia in times of extreme drought.   As boreal mammals and microtine rodents,

southern bog lemmings are poorly adapted to the hot and sometimes dry conditions that dominate the weather in eastern Virginia for the May-September period. Their physical adaptations make dumping heat difficult, forcing them to become primarily nocturnal during the hottest months. Worse still, southern bog lemmings might require more water than other small mammals in the region during the hottest months, in part because of greater water losses for thermoregulation. At present, nothing is known about the renal efficiencies of southern bog lemmings or their tolerances to heat loads compared to meadow voles, for example.

On the positive side, however, southern bog lemmings often readily colonize the early successional habitats that are created when even-aged plantations of loblolly pines are harvested in the region, especially when scattered adult trees remain as the seed sources for revegetating newly logged sites. *Synaptomys* is vagile and readily invades appropriate habitat when its requirements are present. Vagility and modestly broad habitat requirements are useful attributes for a species formerly believed to have been restricted to cool damp swamps. However, when woody logging debris is bulldozed into windrows, seedling pines are planted by machine, and volunteer vegetation is controlled with herbicides, southern bog lemmings are absent from such pine plantations. Dolan (1998) used both live and pitfall trapping methods on fifty-six 0.25 ha sites in pine stands of four age classes in Isle of Wight County, and collected no *Synaptomys* in 39,600 trap nights with live traps and 28,500 trap nights with pitfall traps. This is the same county in which southern bog lemmings were found in 8 of 14 sites in the varied but open habitats under powerlines (Table 2). Thus, forestry methods may be important in determining whether southern bog lemmings can colonize pine plantations during the early years of forest regrowth in eastern Virginia. This speculation is testable.

Overall, then, *Synaptomys cooperi helaletes* is more widespread and abundant in eastern Virginia than previously believed, but it probably deserves to retain its present conservation status because of the rapid land development in the region. Future surveys must use pitfall trapping methods in order to locate populations.

ACKNOWLEDGMENTS

LITERATURE CITED

Beasley, L. E., and L. L. Getz. 1986. Comparison of demography of sympatric populations of *Microtus ochrogaster* and *Synaptomys cooperi*. Acta Theriologica 31:385-400.

Burt, W. H. 1928. Additional notes on the life history of the Goss lemming mouse. Journal of Mammalogy 9:212-216.

Clark, M. K., M. S. Mitchell, and K. S. Karriker. 1993. Notes on the geographical and ecological distribution of relict populations of *Synaptomys cooperi* (Rodentia:Arvicolidae) from eastern North Carolina. Brimleyana 19:144-167.

Connor, P. F. 1959. The bog lemming *Synaptomys cooperi* in southern New Jersey. Publications of the Museum, Michigan State University Biological Series 1:165-248.

Coventry, A. F. 1942. *Synaptomys cooperi* in forested regions. Journal of Mammalogy 23:450-451.

Danielson, B. J., and M. S. Gaines. 1987a. The influences of conspecific and heterospecific residents on colonization. Ecology 68:1778-1784.

Danielson, B. J., and M. S. Gaines. 1987b. Spatial patterns in two syntopic species of microtines: *Microtus ochrogaster* and *Synaptomys cooperi*. Journal of Mammalogy 68:313-322.

Dolan, J. D. 1998. Changes in small mammal community attributes associated with increasing pine stand age in managed pine plantations in southeastern Virginia. M. S. thesis, Old Dominion University, 81 pp.

Everton, R. K. 1985. The relationship between habitat structure and small mammal communities in southeastern Virginia and northeastern North Carolina. M. S. Thesis, Old Dominion University, Norfolk, Virginia. 76 pp.

French, T. W. 1980. Natural history of the southeastern shrew, *Sorex longirostris fisheri* Bachman. American Midland Naturalist 104:13-31.

Gaines, M. S., C. L. Baker, and A. M. Vivas. 1979. Demographic attributes of dispersing southern bog lemmings (*Synaptomys cooperi*) in eastern Kansas. Oecologia 40:91-101.

Gaines, M. S., R. K. Rose, and L. R. McClenaghan, Jr. 1977. The demography of *Synaptomys cooperi* in eastern Kansas. Canadian Journal of Zoology 55:1584-1594.

Getz, L. L. 1961. Factors influencing the local distribution of *Microtus* and *Synaptomys* in southern Michigan. Ecology 42:110-119.

Hall, E. R. 1981. The Mammals of North America, John Wiley and Sons, New York. Volume II, pp. 601-1181.

Hamilton, W. J., Jr. 1941. On the occurrence of *Synaptomys cooperi* in forested regions. Journal of Mammalogy 27:195.

Handley, C. O., Jr. 1979. Mammals of the Dismal Swamp: a historical account. Pp. 297-357 *in* The Great Dismal Swamp (P. W. Kirk, ed.), University Press of Virginia, Charlottesville. 427 pp.

Howell, A. B. 1927. Revision of the American lemming mice (Genus *Synaptomys*). North American Fauna No. 50, U. S. Department of Agriculture, 38 pp.

Krebs, C. J., B. L. Keller, and R. H. Tamarin. 1969. *Microtus* population biology: demographic changes in fluctuating populations of *M. ochrogaster* and *M. pennsylvanicus* in southern Indiana. Ecology 50:587-607.

Lindale, J. 1927. Notes on the life history of *Synaptomys*. Journal of Mammalogy 8:51-54.

Linzey, A. V. 1983. *Synaptomys cooperi*. Mammalian Species 210:1-5.

Linzey, A. V. 1984. Patterns of coexistence in *Synaptomys cooperi* and *Microtus pennsylvanicus*. Ecology 65:382-393.

Linzey, A. V., and J. A. Cranford. 1984. Habitat selection in the southern bog lemming, *Synaptomys cooperi*, and the meadow vole, *Microtus pennsylvanicus*, in Virginia. The Canadian Field-Naturalist 98:463-469.

Meanley, B. 1973. The Great Dismal Swamp. Audubon Naturalists Society, Central

Atlantic States, Washington, D. C., 48 pp.

Merriam, C. H. 1896. Revision of the lemmings of the Genus *Synaptomys,* with descriptions of new species. Proceedings of the Biological Society of Washington, 10:55-64.

Padgett, T. M. 1991. The identification, distribution, and status of the threatened Dismal Swamp shrew (*Sorex longirostris fisheri*). M. S. Thesis, Old Dominion University, Norfolk, Virginia. 59 pp.

Rose, R. K. 1973. A small mammal live trap. Transactions of the Kansas Academy of Science 69:356-357.

Rose, R. K. 1981. *Synaptomys* not extinct in the Dismal Swamp. Journal of Mammalogy 62:844-845.

Rose, R. K. 1983. A study of two rare mammals endemic to the Virginia/North Carolina Dismal Swamp. Final Report, U. S. Fish and Wildlife Service, Annapolis, Maryland. 135 pp.

Rose, R. K. 1994. Instructions for building two live traps for small mammals. Virginia Journal of Science 45:151-157.

Rose, R. K. 2005. The small mammals of Isle of Wight County, Virginia, as revealed by pitfall trapping. Virginia Journal of Science 56:83-92.

Rose, R. K., and M. S. Gaines. 1978. The reproductive cycle of *Microtus ochrogaster* in eastern Kansas. Ecological Monographs 48:21-42.

Rose, R. K., and A. M. Spevak. 1978. Aggressive behavior in two sympatric microtine rodents. Journal of Mammalogy 59:213-216.

Rose, R. K., N. A. Slade, and J. N. Honacki. 1977. Live trap preference among grassland mammals. Acta Theriologica (Poland) 22:197-207.

Rose, R. K., R. K. Everton, J. F. Stankavich, and J. W. Walke. 1990. Small mammals in the Great Dismal Swamp of Virginia and North Carolina. Brimleyana 16:87-101.

Smyth, T. 1946. *Synaptomys cooperi* in southwestern Virginia. Journal of Mammalogy 27:277.

Stankavich, J. F. 1984. Demographic analysis and microhabitat relationships of a small mammal community in clearings of the Great Dismal Swamp. M. S. Thesis, Old Dominion University, Norfolk, Virginia. 118 pp.

Stewart. R. E. 1943. The lemming mouse in Shenandoah Mountains, Virginia. Journal of Mammalogy 24:104.

Taylor, J. W. 1974. The Dismal Swamp lemming mouse. Virginia Wildlife 35:27.

VDGIF (Virginia Department of Game and Inland Fisheries) 2005. Comprehensive Wildlife Conservation Strategy, Chapter 4, Coastal Plain. Richmond, Va. (draft document]

Webster, W. D., A. P. Smith, and K.W. Markham. 1992. A noteworthy distributional record for the Dismal Swamp bog lemming (*Synaptomys cooperi helaletes*) in North Carolina. Journal of the Elisha Mitchell Scientific Society 108:89-90.

Wetzel, R. M. 1955. Speciation and dispersal of the southern bog lemming, *Synaptomys cooperi* (Baird). Journal of Mammalogy 36:1-20.

Wilson, D. E., and S. Ruff. 1999. The Smithsonian Book of North American Mammals. Smithsonian Institution Press, Washington, D. C., 750 pp.

GIS and 3D Analysis Applied to Sea Turtle Mortalities and Navigation Channel Dredging

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ABSTRACT

Between 2000 and 2003 there were an increased number of documented sea turtle mortalities related to hopper dredging in the channels of the Chesapeake Bay. A pilot study was undertaken to create a bathymetric surface and three-dimensional model of the Cape Henry Channel using Geographic Information Systems (GIS) as a visualization tool to examine sea turtle mortalities in relation to the dredging. In Fall 2003, the US Army Corps of Engineers dredged the Thimble Shoals Federal Navigation Channel, and a more refined model was developed using this data. This project examines the growing concerns over sea turtle mortality rates and dredging operations, as well as a description of the usage of GIS analysis, interpolation, and visualization methods as tools for examining turtle habitat and mortality issues. Future directions for incorporating GIS into attempts to reduce sea turtle mortality in dredging operations are then outlined.

INTRODUCTION AND BACKGROUND

The section of the Chesapeake Bay off the Virginia coast contains a series of Federal Navigation Channels that are periodically dredged by self-propelled hopper dredges. These dredges are suitable for all but hard materials and are, by far, the best suited dredges for offshore work (Herbich 2000). There are four main navigation channels in the lower Chesapeake Bay: York Spit, York River Entrance, Cape Henry Channel, and Thimble Shoals Channel. Cape Henry Channel and Thimble Shoals Channel mark the entrance to the Bay from the Atlantic Ocean. The Thimble Shoals and Cape Henry channels are congressionally authorized Federal projects located in the mouth of the Chesapeake Bay between Hampton Roads and the Atlantic Ocean. Thimble Shoals Channel is approximately 18288 meters long, 304.8 meters wide, with an original depth of 13.7 meters at mean low water (CENAO 1973). The channel was constructed in 1914 and requires maintenance dredging once every 2-3 years. Cape Henry Channel is approximately 328 meters wide and 3.7 kilometers long, with an original depth of 12.8 meters at mean low water (CENAO 1980). Figure 1 shows the locations of the Thimble Shoals channel and a portion of the Cape Henry channel as they relate to the Chesapeake Bay coastline region.

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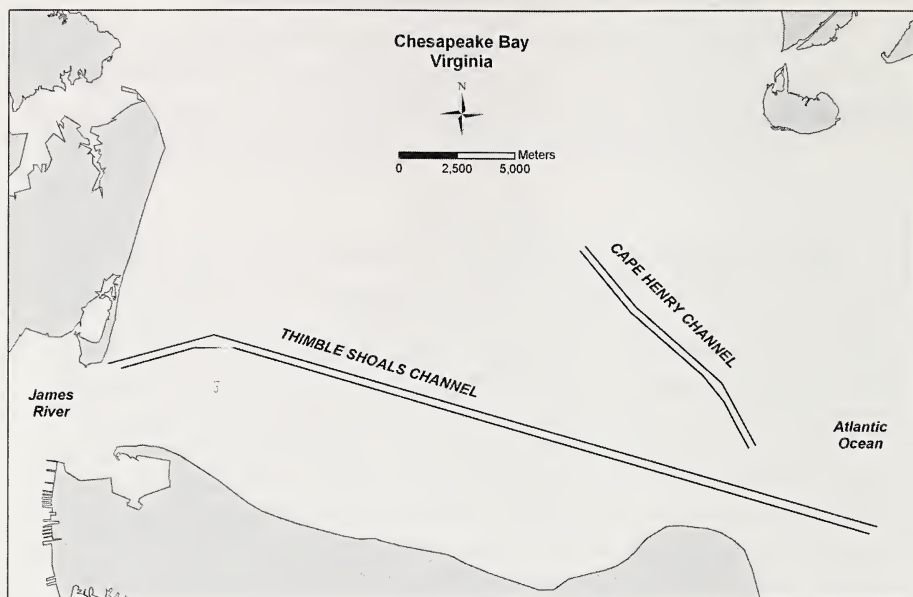[2] Phone: 757-201-7418, keith.b.lockwood@usace.army.mil

FIGURE 1. A plan view map of the Cape Henry and Thimble Shoals Channels

      The Chesapeake Bay is also home to sea turtles, which live in the Bay during the warmer months when the water temperatures remain above approximately 18°C (Keinath *et al.* 1987). Historical aerial surveys conducted in the 1980s estimated that 6,500 to 9,700 sea turtles were found in the lower Chesapeake Bay annually (Byles 1988; Musick 1988; Keinath 1993; Mansfield 2005). Aerial surveys during the period 2001-2004 found a 65-75% reduction in the population estimate, or a range of 2,500 to 5,500 turtles (Mansfield 2005). The majority of turtles that frequent the Bay and come in contact with hopper dredges are loggerhead turtles (*Caretta caretta*) and Kemp's ridley sea turtles (*Lepidochelys kempii*). Hopper dredging can adversely affect sea turtles, either directly by encounters with dredging equipment (which can result in sea turtle mortality) or indirectly by alteration of nesting habitat (Coston-Clements and Hoss 1983).
      In response, several studies have been conducted in coordination with new regulations to protect the threatened and endangered sea turtles. The National Marine Fisheries Service (NMFS) has set guidelines to require relocation trawling if a certain amount of incidents were documented in an allotted time period or within dredging projects. Sea turtle relocation trawling uses shrimp trawlers to move ahead of the hopper dredge collecting sea turtles and depositing them elsewhere (Lincoln 2001). For the Cape Henry and Thimble Shoals Federal Navigation channels of the Chesapeake Bay, relocation trawling must be started if a dredge entrains two sea turtles of any species in a twenty-four hour period or if four sea turtles are caught during a two- month time period (Kurku, 2002).

The Cape Henry and Thimble Shoals channels were chosen for the area of study for several reasons. First, the Army Corps of Engineers dredged the Thimble Shoals channel in Fall 2003 and the Cape Henry channel one year earlier. The threshold on sea turtle mortalities was reached (Mansfield and Musick 2004), and trawlers began working in front of the dredges. Also, the channels mark the entrance to the Chesapeake Bay, which may act as funnels for turtles migrating in and out of the Bay during the spring and fall. Therefore, the Cape Henry and Thimble Shoals channels are ideal for studies of the relationship between sea turtles and dredging. In this project, the Cape Henry channel operation is presented as a pilot study, while gaps or discrepancies in the data were corrected for the relevant information collected for the Thimble Shoals channel. Data recorded on the observer reports on both the dredges and trawlers were heavily scrutinized for discrepancies, and thus data accuracy was greatly improved from the previous Cape Henry project.

Several projects have examined turtle mortalities and catches from trawling and fishing gear. Casale *et al.* (2004) examined turtle catches from trawling in the Adriatic Sea, while Robins (1995) provides estimations for the turtle catches off the shore of Australia. Cheng and Chen (1997) examine sea turtle catches from fisheries in coastal areas of Taiwan. Robins- Troeger *et al.* (1995) discuss the success of a TED (Turtle Excluder Device) used in Australia to reduce and prevent turtles being caught by trawlers. The TED acts as an escape hatch for sea turtles caught in a trawler's net and when used on a dredge acts as a plow pushing sea turtles out of the way of the drag head as it moves along the bottom.

Other studies have spawned from the increases in sea turtle mortalities. The Virginia Institute of Marine Science (VIMS) began tagging sea turtles to trace their surfacing and traveling patterns (Mansfield and Musick 2002). Results from this study provides researchers information on turtle migration patterns, surfacing behaviors, and the maximum number of individual turtles (per species) that may be taken incidentally by anthropogenic activities, such as hopper dredging, while still allowing for the recovery of the species (TEWG 2000; Mansfield 2005). The U.S. Army Corps of Engineers (USACE) Norfolk District maintains a database of turtle catches by both dredges and relocation trawlers in the Chesapeake Bay Federal Navigation Channels. From the period when monitoring began in 1994 to 2003, 55 sea turtle were incidentally taken by hopper dredging activities in the Chesapeake Bay. An additional 61 sea turtles were caught by a trawler working in one of the four navigation channels, and relocated approximately 8.05 kilometers away from the respective channel. The USACE maintains a Microsoft Access database that includes fields representing the location of catches in various coordinate systems, the date and time, type of vessel, water and air temperature, condition of specimen, tide, and several other attributes while the coordinates of a turtle take are recorded when the event occurs. The database has a live link with Geographic Information Systems (GIS) software in order to portray a point shapefile of turtle takes in the Chesapeake Bay. Figure 2 shows a map of the Chesapeake Bay with the channels, as well as the historic turtle takes attributed to water temperature for 2002. Another map portrays the same points, but attributed to type of vessel, whether dredge or trawler (Figure 3).

Team members on the project are concentrating on the technical aspects of the dredge equipment to identify any changes that can be made to prevent turtle mortalities.
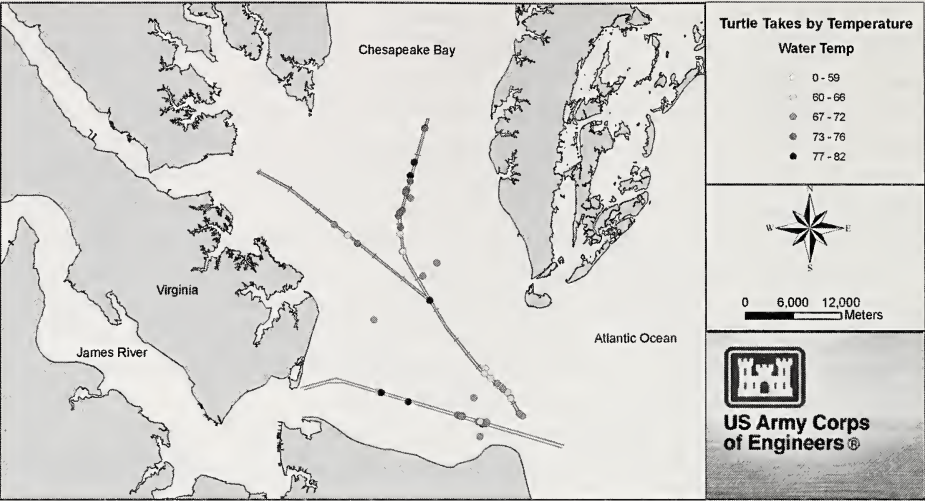
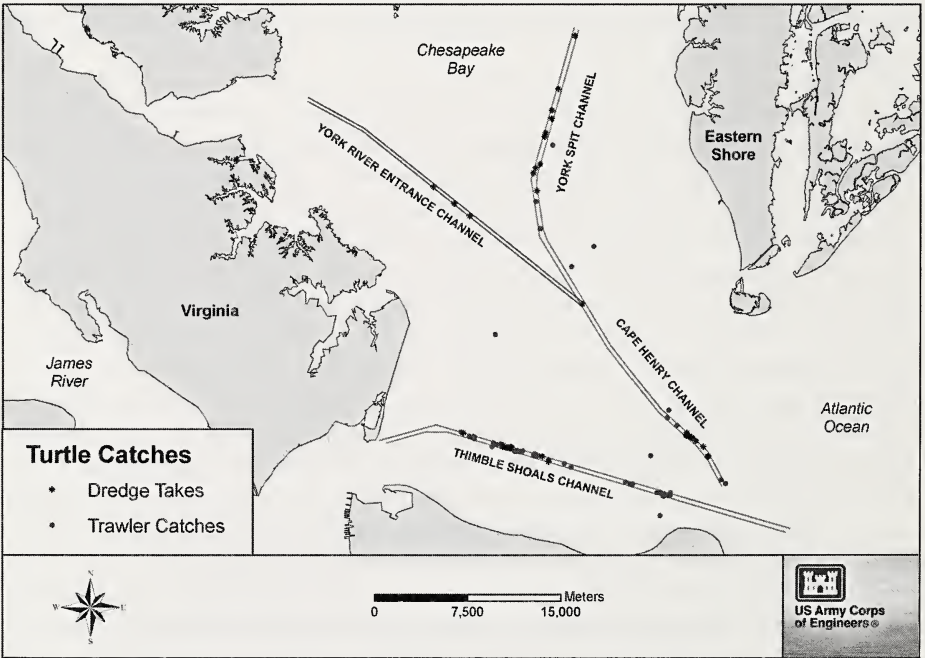FIGURE 2. The channels of the Chesapeake Bay and turtles takes attributed to water temperature for 2002.

FIGURE 3. Turtle takes attributed to type of vessel (dredge or trawler)

Even though hopper dredges can entrain sea turtles, this type of vessel is used as it is the most efficient type of equipment for dredging unprotected offshore channels (Kurkul 2002). A hopper dredge has a drag head that acts like a vacuum on the bottom sucking up sediments, and turtles can get entrained or crushed by the suction capacity of the drag head. One major modification was a turtle deflector, located on the drag head of the dredge. It acts as a plow that digs into the bottom approximately six inches, and pushes anything on the surface of the bottom out of the way (Fonferek 2001). The rigid deflector, properly installed and operated, blocked 95 percent of mock turtles in a field test experiment performed by the Army Corps of Engineers (USACE 1997). Also, dredging specifications have altered because of the turtle conflict; now dredging operators shall not have the pumps running if the drag head is not in contact with the bottom. GIS has been incorporated with dredging operations to model dredged material mounds and sediment concentrations, such as the SSFATE model (Howlett 2003; Swanson *et al.* 2004), although these models are focused on the physical dredging and disposal operations and have not been connected to marine life interactions.

GIS and related technologies have been integrated with sea turtle analysis and studies of the turtles in various ways. Many projects have used satellites to track the movement of sea turtles based on tags the turtles have been outfitted with. Satellites are then used to track the signals from the transmitting units on the turtles (Godley *et al.* 2002; Echols 2003; Mansfield and Musick 2004) for locating their position. Using this information, the movements of turtles can be tracked to determine where turtles are going and when they are going there. Broderick and Godley (1999) also identify potential negative impacts on the turtles from these tracking efforts, but note that tagging did not interfere with sea turtle nesting behaviors. Beyond tracking and analysis, GIS has been used for modeling of turtle habitats. McDaniel *et al.* (2000) use GIS for models of predicting turtle abundance and density. Chaloupka (2002) provides a model for examining population dynamics of turtles in the Great Barrier Reef, however this does not take spatial features into account. This paper seeks to provide additional applications of the technology beyond these efforts.

This paper also provides an examination of the relationship between sea turtles in the region and the dredging operations. In order to aid in exploration of this process, GIS techniques are used to construct bathymetric surfaces and three-dimensional visualizations of the dredged areas to examine sea turtle mortalities in relation to the bathymetry of the channels. The surfaces provide a measure of the bathymetry associated with the available turtle take data which remains unrecorded during surveys. These new visualizations can potentially aid in the attempt to curb sea turtle mortalities with examination of locations of sea turtles with respect to the bottom surface. These tools can also be extended to uses beyond turtle mortalities and can prove adaptable to many types of habitat-based scientific research.

MATERIALS AND METHODS

To create a surface representing a section of a channel where sea turtles were entrained or captured, base heights for the bottom of the channel must be established. Several studies have incorporated geospatial techniques into working with bathymetric
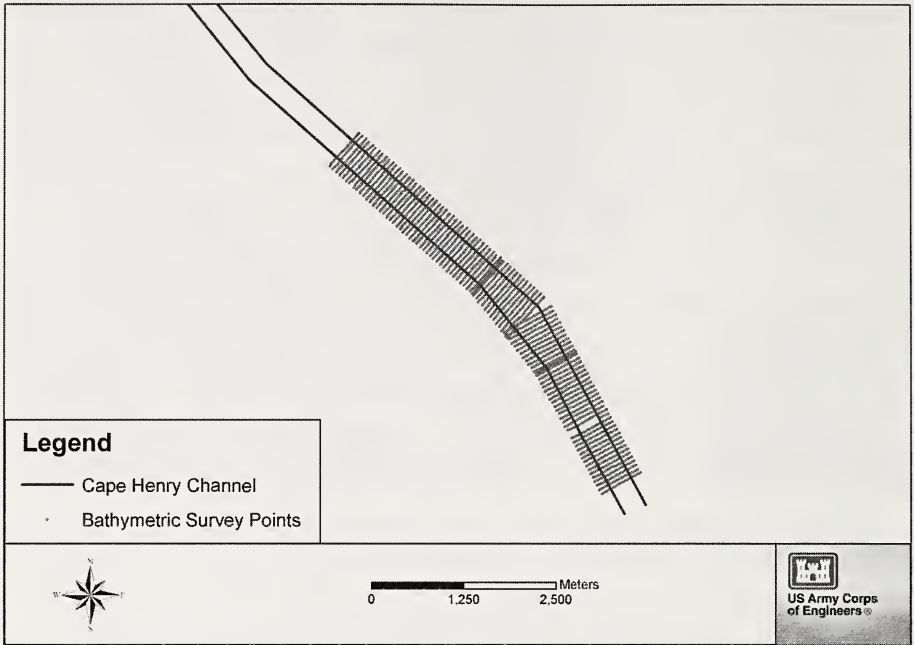
FIGURE 4. The locations of the survey depth sample points for Cape Henry Channel

surfaces to aid in analysis including Pang *et al.*'s (2003) use of a linear interpolation method to create a bathymetric surface, Guitton and Claerbont's (2004) methods for reducing noise in bathymetric data, and Kozlenko and Jeffries (2000) utilization of remotely sensed SAR (synthetic aperture radar) images to produce bathymetric surfaces. Gesch and Wilson (2002) and Parker *et al.* (2001) discuss the use of blending gridded datasets of different elevation surfaces from both bathymetry and topography together.

The project described in this study utilized a series of bathymetric measurements gathered by regular Army Corps of Engineers surveys performed on all navigation channels at various times throughout the year, which record the depth of sections of the channel. The location and depth data for sea turtle incidental takes was gathered at continuous time intervals by Silent Inspector software onboard the dredges, which were in turn supplemented by observer reports for the trawlers. This point data was transferred to CAD (Computer Aided Design) drawings that were merged together creating into a single GIS shapefile for the sections of the channels being studied (Figure 4), while other shapefiles were created to show the best available spatial data representing the turtles that were captured by both dredges and trawlers.

A notable element unrecorded by the surveys is the bathymetric depth for the turtle take reading. To aid in accounting for this, ArcGIS interpolation methods were used to create the bathymetric surface of the channels (which were then fashioned into 3D representations). These processes use points with known values (i.e. the readings of bottom elevation from the surveys) to estimate values at other points (for which survey

information was not collected), and to create a surface that shows a visual representation of what a channel looks like underwater. Interpolation methods are commonly utilized to create bathymetric surfaces for use in GIS analysis and several are available for use in ArcGIS with its 3D Analyst extension. These methods calculate values for the unknown locations based upon known values, thus creating an elevation surface from a sampling of points (Bratt and Booth 2004). The goal of this paper is to demonstrate the usefulness of the interpolation methods of ArcGIS for visualization purposes, not to provide a methodological examination of the methods, nor to delve into the mathematics behind them (see Isaaks and Srivastava 1989 for an excellent reference on geostatistical methods).

ArcGIS allows the creation of surfaces as TINs (Triangulated Irregular Networks), a surface generation method which takes the points as the source of elevation / depth values and interpolates the faces that make up the surface between the points (Bratt and Booth 2004). TINs have been utilized in bathymetric surface generation (Zhang and Yang 2006; Johnston 2003; Byrnes et al. 2002), especially when depth values are unevenly distributed across the area (Byrnes et al. 2002).

ArcGIS gives the user several other interpolation options for use in creating a surface from a series of points. The first of these is Inverse Distance Weighting (IDW) a process that assumes that those known values closer in distance to the unknown point are weighted heavier in determining the unknown value than those points further away (Bratt and Booth 2004). A second method is Kriging (Isaaks and Srivastava 1989; Johnston 2003), a process used to fit a model to the data based not only the distance between the points but also the spatial arrangement among the known points (McCoy and Johnston 2001). This modeling of spatial dependence comes in the form of a semivariogram (Johnston et al. 2001). With Kriging, a semivariogram is used to examine the fit of the points to the model, and three values used to fit this semivariogram: range (limit of spatial dependence), sill (the value at which the range is reached), and the nugget (the value for the semivariance when the distance is zero). Using these variables, the semivariogram can be fit to the data and the weights for each unknown point can be calculated (Isaaks and Srivastava 1989; Chang 2004). The form of Kriging known as Universal Kriging accounts for overriding trends (or drift) in the data by first removing the trend and then performing Kriging on the residuals.

Splines are another interpolation method suggested for use in determining elevation surfaces (Bratt and Booth 2004). The surface created through Spline methods can be conceived as bending and stretching a rubber sheet to pass through all points on the surface while trying to minimize the curvature and thus be as smooth as possible (Mitasova et al. 1995; Bratt and Booth 2004). Splines can take one of two forms: tensioned (where the elasticity of the surface can be controlled) and regularized (where the smoothness of the surface can be controlled) (Bratt and Booth 2004). Hargrove et al. (1995) successfully utilized Splines in the interpolation of a bathymetric surface, while Mitasova et al. (1995) used Splines to create bathymetric surfaces in conjunction with other studies of the Chesapeake Bay region.

The generated surfaces can be rendered in pseudo-3D through the use of the ArcScene tool in ArcGIS' 3D Analyst. In 3D analysis, the z-values of the surface (in this case, representing bathymetric depths) are utilized as base heights, and those base heights applied to the surface itself to create a 3D rendering of the surface (Bratt and

TABLE 1. Sample of 2002 Turtle Catches (by dredge and trawler) from Cape Henry (source: US Army Corps of Engineers, Norfolk District)

ID	Date	Time	Water Temp	Air Temp	Dredge Name	Turtle Species
37	04/24/2002	1114	57°F		Bayport	Loggerhead
38	05/13/2002	1000	66°F		Bayport	Loggerhead
39	05/18/2002	1946	65°F		Bayport	Loggerhead
40	05/23/2002	0555	61°F		Bayport	Loggerhead
41	06/01/2002	2112	71°F		Bayport	Green
42	06/04/2002	2227	70°F		Bayport	Loggerhead
61	10/26/2002	1437	65°F	64°F	Relocation Trawler	Green
62	10/26/2002	2256	65°F	64°F	Relocation Trawler	Kemp's Ridley
63	10/31/2002	1512	60°F	48°F	Relocation Trawler	Loggerhead
64	10/31/2002	1600	60°F	48°F	Relocation Trawler	Loggerhead

Booth 2004). The survey values were multiplied by a value of -1 to create negative numbers to that the vertical depth of the channel areas could be properly viewed in 3D.

RESULTS

A sample of the turtle take information from the 2002 dredging and trawling operations in Cape Henry Channel is presented in Table 1. Note that the information in these tables provides basic information as to the time, temperature, and species of turtle (where this information is available). The ten turtle catches listed in the table are represented in the bathymetry model of the Cape Henry Channel.

Unfortunately, the exact locations of the actual turtle take cannot be determined as the turtles are discovered at the end of a dredge or trawl transect. To maintain consistency, the locations of turtle takes are recorded at the end of the transect where the turtle was observed entrained by a dredge, or caught in a trawler. While this does not provide the exact location of the turtle capture, it provides the best available approximation of the location.

Six versions of the bathymetry of Cape Henry Channel were created using a variety of different methods from the ArcGIS 3D Analyst: IDW, Ordinary Kriging, Universal Kriging, Tensioned Splines, Regularized Splines, and a TIN (Figure 5). In order to validate which surfaces best fit the bathymetry, a source for comparison was needed. Unfortunately USACE survey contours are based on 50' contours, creating generalized maps, and thus would not provide a proper comparison. For general visual comparison purposes, USGS Digital Raster Graphics (DRGs) showing the bathymetry of the areas were used in comparing sections of the generated surfaces to available sections of the bathymetric contours shown on the DRGs. While no surface was a match for the generalized contour profile represented by the DRGs, the Ordinary Kriging, Tensioned Splines, IDW, and TIN surfaces better approximated selected sections of the contours
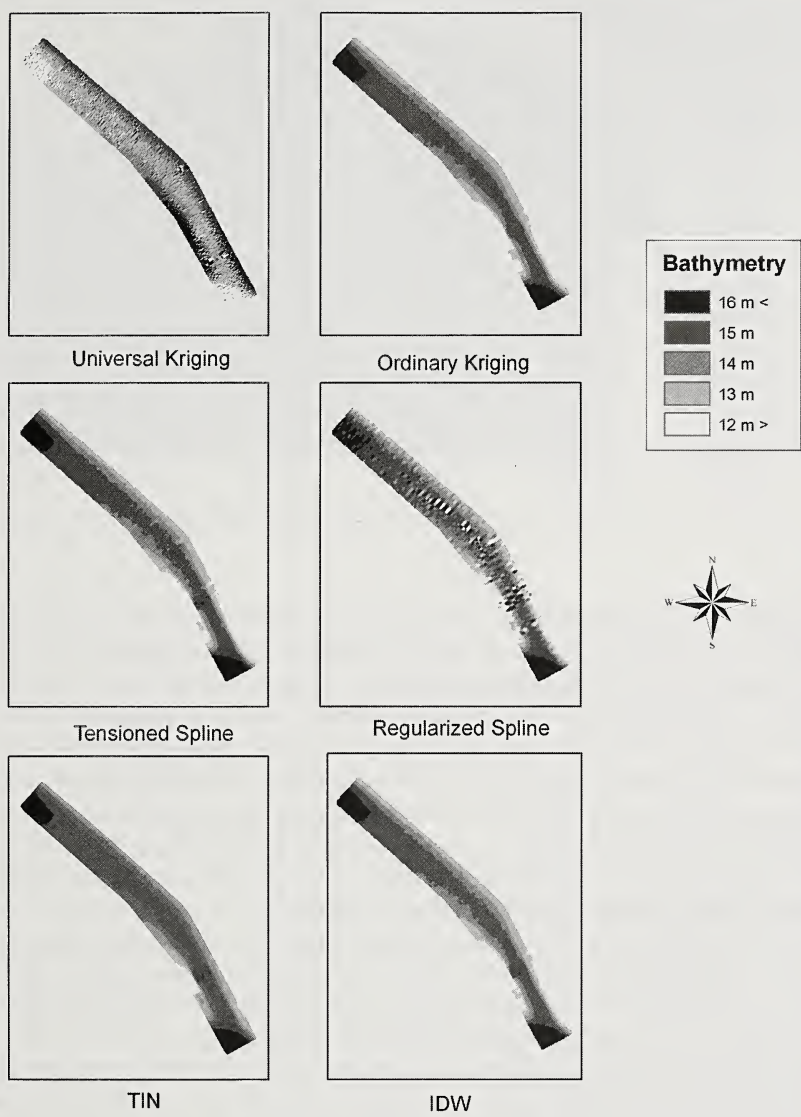
FIGURE 5. The Cape Henry Channel bathymetry created through several GIS methods

than the other surfaces. Possibly due to the spatial arrangement and distribution of the survey points, the Universal Kriging and Regularized Splines generated surfaces inconsistent with the others that did not provide an approximation of the DRG contours. However, as Table 2 shows, all surfaces generated similar values for bathymetry in relation to the turtle take locations, with few deviations.

TABLE 2. Sample of 2002 Turtle Catches (by dredge and trawler) from Cape Henry matched against bathymetric readings (in meters) from interpolated surfaces (source of turtle data: US Army Corps of Engineers, Norfolk District)

ID	Ordinary Kriging	Universal Kriging	Tensioned Spline	Regularized Spline	TIN	IDW
37	-15.3293	-15.6929	-15.3522	-15.5716	-15.3180	-15.3397
38	-15.0846	-15.0961	-15.0251	-15.0199	-15.0346	-15.0562
39	-15.3125	-15.2656	-15.2525	-15.1086	-15.2714	-15.3461
40	-14.9227	-14.9794	-14.8813	-13.9836	-14.9398	-14.8361
41	-14.8916	-14.9401	-14.9812	-14.9824	-14.9873	-15.0468
42	-15.0711	-12.0506	-15.0687	-15.2741	-15.0763	-15.1007
61	-15.3028	-15.3473	-15.3580	-15.1568	-15.3714	-15.3363
62	-15.1236	-15.2613	-15.0745	-14.9547	-15.1239	-15.3385
63	-15.7182	-15.8246	-15.7082	-16.0291	-15.6740	-15.8191
64	-15.3317	-15.3363	-15.3452	-15.3497	-15.3305	-15.3330

Shapefiles representing the locations of the turtle takes were generated and overlaid on each of the surfaces. As depth readings for turtle takes were not recorded by the dredges, the generated surfaces provide a bathymetric reading for the depth of each turtle. Table 2 shows each turtle take and the bathymetry assigned to it by each generated surface. The turtle take locations represent the best possible known location of where the turtle take occurred and it is these locations that can then be correlated to the bathymetry. These values can then be appended to the previous tables using GIS to create a more complete survey. As can be seen in Table 2, the interpolated depths were usually consistent with each other, with the exception of some readings from the Universal Kriging and Regularized Splines surfaces.

Lastly, ArcGIS was used to render the Cape Henry channel for a 3D representation of the area. The turtle take shapefile was converted to a 3D shapefile and overlaid in each of the channels for a representative view of the depth reading available for where each dredge or trawler entrained a sea turtle. Figure 6 shows the Cape Henry Tensioned Spline surface in a 3D view in ArcScene. Note a vertical exaggeration of 75 is applied to the image to visually adjust for the relatively small base height differences in the channels.

The same processes were applied to construct an interpolated surface and 3D visualization of the Thimble Shoals area to demonstrate the usefulness of the data and methods. Although no turtle takes occurred in this particular section of the Thimble Shoals channel during the 2003 survey, turtles have historically been entrained in the area as well as other portions of the channel. Figure 7 shows the locations of the survey points for Thimble Shoals Channel, while Figure 8 shows a section of the 3D view of Thimble Shoals (generated from the Tensioned Spline surface).
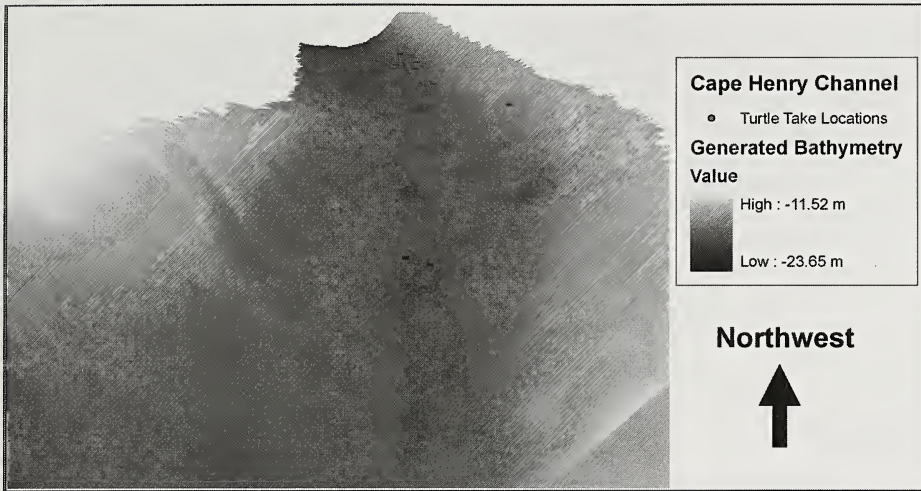
FIGURE 6. The 3D view of the Cape Henry Channel

This type of GIS visualization can be used for creation of real-time "fly-throughs" of the channel and is ideal for presentations where areas of a channel, such as bottom irregularities or turtle take locations, need to be more closely examined. The surfaces and 3D visualizations created with GIS provide researchers supplementary data and tools to be used in conjunction with the turtle take data. First, a model of the Cape Henry and Thimble Shoals channels illustrates where turtles may be frequenting an area, as well as the type of bathymetry at that location. Secondly, dredging engineers can use the results to see where historical interactions with sea turtles occurred, and design ways to minimize impacts on future projects. The 3-dimensional modeling provides a better basis for visualization of the bottom depths than a standard 2-dimensional map would, enabling better examination of the surface bottom with relation to turtle mortality sites. This enhanced visualization would be of use for examining the   format of the bathymetry rather than a regular contour map.

DISCUSSION AND CONCLUSIONS

The goal of this paper was to provide a set of GIS techniques for surface generation and 3D visualization that can be used for better understanding of the relationship between turtles and dredging, as well as to act as a basis for future projects. GIS can be used as a way to store, manipulate, analyze, and visualize information related to coastal issues, and its importance is realized in this project. GIS has been used to incorporate transcribing the information from reports into a database and further analysis of the relationship between sea turtles and hopper- dredging operations results from these uses of GIS. For example, prior to Fall 2002, observer and trawling reports documenting sea turtle incidents in the Chesapeake Bay navigation channels were bound in hard copy reports. These reports were often tedious to analyze and use, and therefore filed away. Storing the data in a GIS database allows engineers and
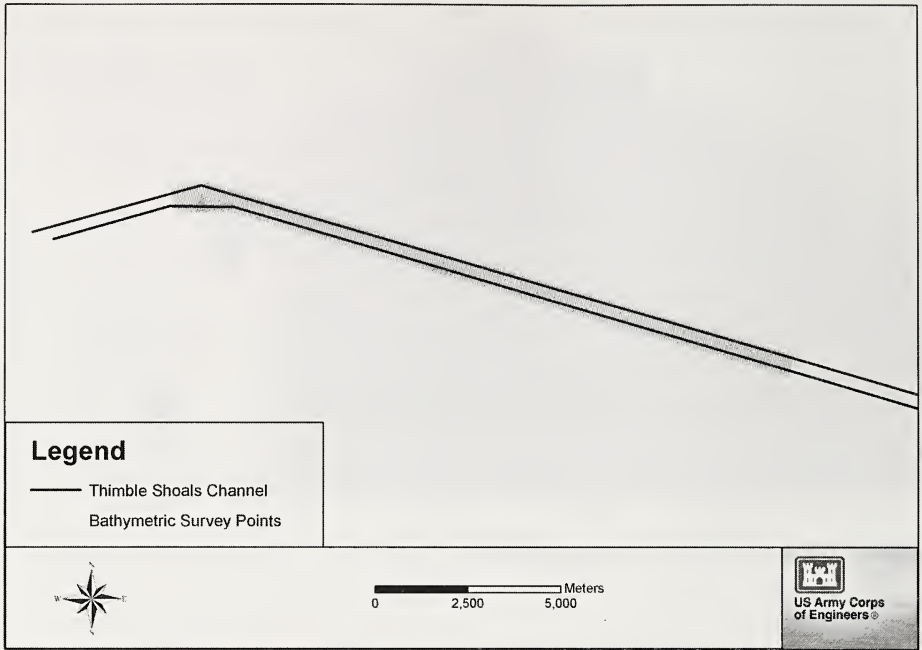
FIGURE 7. The locations of the survey depth sample points for Thimble Shoals Channel

scientists to use the information to discover trends and make better decisions. Once all the information representing important factors has been recorded, GIS can be used to manipulate the data in a multitude of ways.

For the Cape Henry / Thimble Shoals project, the main objective was to use GIS to create a visualization of the channels with the sea turtle incidents overlaid. The Thimble Shoals project provides a better realization than the Cape Henry project due to the increase in data accuracy. For the Cape Henry project, data used was collected before the project began, while for the Thimble Shoals project, data was collected in an ongoing fashion; thus data quality could be immediately checked and any errors could be corrected.

The project performed for the Cape Henry channel in 2002, and refined for the Thimble Shoals channel in 2003, can be used as a template for future projects that looks at certain trends that the model may suggest. A visualization model provides opportunities to present valuable information that cannot be depicted through hard-copy reports. Other modeling efforts examining benthic habitats (Bjorgo *et al.* 2001) note that the 3-dimensional imagery serves as a useful tool for management and analysis. All the necessary information for each sea turtle incident is stored in a database with a direct feed to the GIS project. In addition, steps can be taken to narrow down areas in the models that should be given a closer look. For instance, if a shoal forms in the Thimble Shoals channel, then that section of the channel needs dredging. In order to understand the history of sea turtle incidents in that area, with complementing factors such as water temperature, location, date, and tide, the GIS can
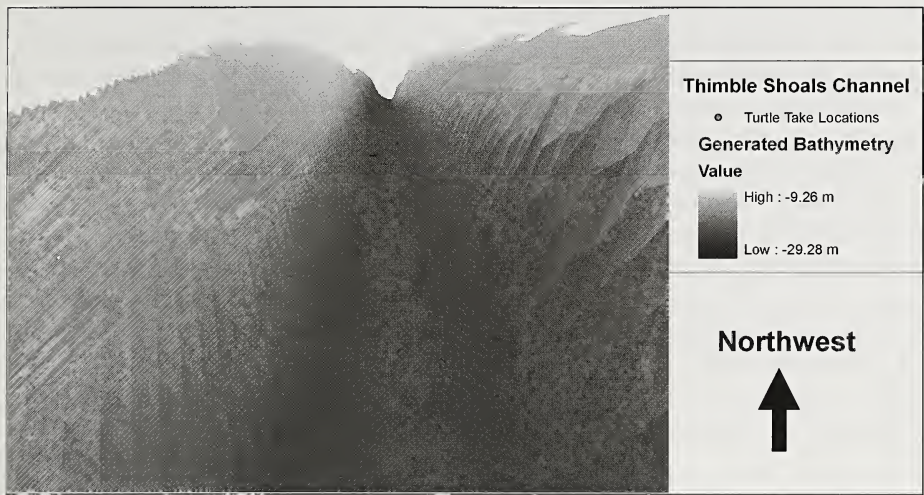
FIGURE 8. A 3D view of the Thimble Shoals Channel.

be used to focus on the shoaled section of the channel. This will increase the efficiency of discovering useful trends, and provide for more effective decision-making. However, since neither relocation trawling nor dredging occurred continuously throughout the project, gaps remain in the data.   Therefore, certain trends or assumptions based on why, where, or when sea turtles were captured cannot be conclusive, instead they should act as red flags for more intensive study.

The interpolated surfaces and 3D models created in this project can be used as a platform for future studies in applications of GIS to the sea turtle mortality problem. For example, Mansfield *et al.* (2001) identified that water temperature and time of year are important independent factors that can be used to predict the probability of sea turtles using certain areas.   Future applications of the techniques presented in this project can move further forward by manipulating the water temperatures recorded for the sea turtle incidents. A more specific temperature range or trend could be established in conjunction with bathymetry, and used when scheduling dredging projects.

Also, a factor that has been recorded, but not yet studied with intensity, is the forage base, or food source, for sea turtles. In the Thimble Shoals study, prioritizing the criteria recorded, such as putting more focus on bycatch (the biological material or organisms that are caught during the trawling haul or dredging cycle) numbers, would allow for more factors to be analyzed in connection with sea turtle takes.   On each trawling and dredging report, observers record the amount and type of bycatch. Sea turtles may be using an area due to food availability, such as blue crabs (Calinectes sapidus) and horseshoe crabs (Limulus polyphemus). Recording the numbers of crabs caught could end up having a positive relationship with the number of sea turtle incidents in the area. It is known that sea turtles forage on blue crabs, horseshoe crabs, and channel and knobbed whelk (Busycon canaliculatum; Busycon caricas) (Seney 2003; Seney and Musick 2005). Therefore, creating a surface of sea turtle food source bycatch could potentially produce a positive trend. This trend may prove that increases

in food source bycatch correlate with an increase in sea turtle takes. Dredging engineers could then use bycatch as another indicator for the probability of sea turtles being in the area. The use of just one of the various indicators would not be very effective, but by combining the various indicators, such as food source, bathymetry, water temperature, and time of year in a GIS, a solid probability portraying sea turtle use may be extremely useful and valid.

Ultimately, this project is an example of the type of work that must be accomplished in order for us to utilize our natural resources without adversely affecting them. The use of GIS and the related interpolation and visualization techniques have numerous applications far beyond modeling turtle habitats and mortalities and are certainly not limited to them. These types of tools have a broad scope and applicability to a host of problems. This project incorporates many methods together under the umbrella of GIS (database management, surface modeling, and 3D visualization) and through combining these methods in GIS, their functionality becomes greatly increased.

LITERATURE CITED
Bjorgo, K.A., M.P. Strager and K. Hartman. 2001. Use of GIS to Characterize Large River Benthic Habitat. Proceedings of the 21st Annual ESRI User Conference. July 9-13, 2001.

Bratt, S. and B. Booth. 2004. Using ArcGIS 3D Analyst. Redlands: ESRI Press.

Broderick, A. and B.J. Godley. 1999. Effect of tagging marine turtles on nesting behaviour and reproductive success. Animal Behavior 58:587-591.

Byles, R. A. 1988. The Behavior and Ecology of Sea Turtles in Virginia [dissertation]. Virginia Institute of Marine Science, College of William and Mary, Gloucester Point, VA. 112 p.

Byrnes, M.R., J.L. Baker and F. Li. 2002. Quantifying potential measurement errors associated with bathymetric change analysis. Vicksburg: Mississippi: US Army Engineer Research and Development Center. ERDC/CHL CHETN-IV-50.

Casale, P., L. Laurent and G. De Metrio. 2004. Incidental capture of marine turtles by the Italian trawl fishery in the north Adriatic Sea. Biological Conservation 119:287-295.

CENAO (Corps of Engineers, Norfolk District Office). 1973. Final Environmental Statement. Thimble Shoal Channel (Maintenance Dredging). Army Corps of Engineers, Norfolk District.

CENAO (Corps of Engineers, Norfolk District Office). 1980. Joint Federal/State Public Notice 33 CFR 209.145. Army Corps of Engineers, Norfolk District.

Chaloupka, M. 2002. Stochastic simulation modeling of southern Great Barrier Reef green turtle population dynamics. Ecological Modeling 148:79-109.

Chang, K. 2004. Introduction to Geographic Information Systems (2nd edition). New York: McGraw Hill.

Cheng, I. and T. Chen. 1997. The Incidental Capture of Five Species of Sea Turtles by Coastal Setnet Fisheries in the Eastern Waters of Taiwan. Biological Conservation 82:235-239.

Coston-Clements, L. and D.E. Hoss. 1983. Synopsis of data on the impact of habitat alteration on sea turtles around the southeastern U.S. NOAA Technical Memorandum NMFS-SEFC-117.

Echols, D. 2003. Satellite Tracking of Endangered Kemp's Ridley Sea Turtles. National Park Service. http://www.nps.gov/gis/mapbook/tech/144.html (July 21, 2003).

Fonferek, B. 2001. Hopper Dredge Sea Turtle Deflector Draghead and Operational Requirements. U.S. Army Corps of Engineers, Jacksonville, FL. http://www.saj.usace.army.mil/pd/turtle.htm (17 January 2001).

Gesch, D. and R. Wilson. 2002. Development of a seamless multisource topographic/bathymetric elevation model of Tampa Bay. Marine Technology Society Journal 35(4):58-64.

Godley, B. J., S. Richardson, A.C. Broderick, M. S. Coyne, F. Glen and G. C. Hays. 2002. Long term satellite telemetry of the movements and habitat utilization by green turtles in the Mediterranean. Ecography 25:352-362.

Guitton, A. and J. Claerbout. 2004. Interpolation of bathymetry data from the Sea of Galilee: a noise attenuation problem. Geophysics 69(2):608-616.

Hargrove, W. W., F. M. Hoffman and D. A. Levine. 1995. Interpolation of Bottom Bathymetry and Potential Erosion in a Large Tennessee Reservoir Using GRASS. Proceedings of the Ninth Annual Symposium on Geographic Information Systems. GIS World, Inc., Vancouver, British Columbia, Canada. pp. 552-557.

Herbich, J. B. 2000. Handbook of Dredging Engineering, Second Edition. New York, NY: McGraw-Hill.

Howlett, E. 2003. GIS-based tools in support of Dredging Operations. Sea Technology 44(3):42-44.

Isaaks, E. H. and R. M. Srivastava. 1989. An Introduction to Applied Geostatistics. New York: Oxford.

Johnston, K., J. M. Ver Hoef, K. Krivoruchko and N. Lucas. 2001. Using ArcGIS Geostatistical Analyst. Redlands: ESRI Press.

Johnston, S. 2003. Uncertainty in bathymetric surveys. Vicksburg: Mississippi: US Army Engineer Research and Development Center. ERDC/CHL CHETN-IV-59.

Keinath, J. A. 1993. Movements and Behavior of Wild and Head-Started Sea Turtles [disseration]. School of Marine Science, College of William and Mary, Gloucester Point, VA. 206 pp.

Keinath, J. A., J. A. Musick and R. A. Byles. 1987. Aspects of the biology of Virginia's sea turtles: 1979-1986. Virginia Journal of Science 38(4):329-336.

Kozlenko, N. and M. O. Jeffries. 2000. Bathymetric Mapping of Shallow Water in Thaw Lakes on the North Slope of Alaska with Spaceborne Imaging Radar. Arctic 53(3):306-316.

Kurkul, P. 2002. Consultation on Dredging in the Thimble Shoal Federal Navigation Channel and Atlantic Ocean Channel. Biological Opinion from National Marine Fisheries Service, Northeast Regional Office to the Army Corps of Engineers, Norfolk District, Norfolk, VA.

Lincoln, E. 2001. Saving the Sea Turtles: NOD undertakes new measures to protect endangered loggerhead species. Riverside 12(11):6-7.

Mansfield, K. L. 2005. Sources of Mortality, Movements and Behavior of Sea Turtles in Virginia [dissertation]. School of Marine Science, College of William and Mary, Gloucester Point, VA. 367 pp.

Mansfield, K. L. and J. A. Musick. 2002. Loggerhead Sea Turtle Diving Behavior. Final Contract Report from the Virginia Institute of Marine Science to the Army Corps of Engineers, Norfolk District, Norfolk, VA.

Mansfield, K. L. and J. A. Musick. 2004. Sea Turtle Diving Behavior in Virginia. Final Contract Report from the Virginia Institute of Marine Science to the Army Corps of Engineers, Norfolk District, Norfolk, VA.

Mansfield, K. L., J. A. Musick and S. M. Bartol. 2001. Internesting Movements of Loggerhead (Caretta caretta) Sea Turtles in Virginia, USA. Proceedings of the 21st Annual Sea Turtle Symposium. NOAA Tech. Memo.

McCoy, J. and K. Johnston. 2001. Using ArcGIS Spatial Analyst. Redlands: ESRI Press.

McDaniel, C. J., L. B. Crowder and J. A. Priddy. 2000. Spatial dynamics of sea turtle abundance and shrimping intensity in the U.S. Gulf of Mexico. Conservation Ecology 4(1):15.

Mitasova, H., L. Mitas, W. M. Brown, D. P. Gerdes and I. Kosinovsky, I. 1995. Modeling spatially and temporally distributed phenomena: New methods and tools for GRASS GIS. International Journal of Geographical Information Science 9(4):443-446.

Musick, J. A. 1988. The sea turtles of Virginia : with notes on identification and natural history, 2nd revised edition. Virginia Sea Grant Program, Virginia Institute of Marine Science, Gloucester Point, VA. 20 pp.

Pang, W. C., P. Tkalich and E. S. Chan. 2003. Hydrodynamic forecast model for the Singapore Straits. Proceedings of the XXX IAHR Congress, August 2003, Thessaloniki, Greece, pp.9-16.

Parker, B., D. G. Milbert, R. Wilson, K. W. Hess, R. Berry, C. Fowler and D. Gesch. 2001. A Tampa Bay Bathymetric/Topographic Digital Elevation Model with Internally Consistent Shorelines for Various Datums. Proceedings of the Twelfth Biennial International Symposium of the Hydrographic Society, University of East Anglia, Norwich, UK, 2001, pp. 11-1 to 11-11.

Robins, J. B. 1995. Estimated Catch and Mortality of Sea Turtles From The East Coast Otter Trawl Fishery of Queensland, Australia. Biological Conservation 74:157-167.

Robins-Troeger, J. B., R. C. Buckworth and M. C. L. Dredge. 1995. Development of a trawl efficiency device (TED) for Australian prawn fisheries. II. Field evaluations of the AusTED. Fisheries Research 22:107-117.

Seney, E. E. 2003. Historical Diet Analysis of Loggerhead (Caretta caretta) and Kemp's Ridley (Lepidochelys kempii) Sea Turtles in Virginia [masters thesis].

School of Marine Science, College of William and Mary, Gloucester Point, VA. 123 pp.

Seney, E. E. and J. A. Musick. 2005. Diet Analysis of Kemp's ridley sea turtles (Lepidochelys kempii) in Virginia. Chelonian Conservation and Biology 4(4):864-871.

Swanson, J. C., T. Isaji, D. Clarke and C. Dickerson. 2004. Simulations of Dredging and Dredged Material Disposal Operations In Chesapeake Bay, Maryland, and Saint Andrew Bay, Florida. WEDA XXIV / 36th TAMU Dredging Seminar. Orlando, FL, July 6-9, 2004.

TEWG (Turtle Expert Working Group). 2000. Assessment Update for the Kemp's Ridley and Loggerhead Sea Turtle Populations in the Western North Atlantic. US Dept. of Commerce. NOAA Tech. Memo. NMFS-SEFSC-444. 115 pp.

USACE (United States Army Corps of Engineers). 1997. Development and Evaluation of a Sea Turtle-Deflecting Hopper Dredge Draghead. US Army Corps of Engineers, Technical Report CHL-97-31, pp. 87-92.

Zhang, T. and X. Yang. 2006. Analyzing Historical Bathymetric Change in Tampa Bay, Florida: A Preliminary Study. Papers of the Applied Geography Conferences 29:87-95.

2006 Best Student Paper Awards

Astronomy, Mathematics, and Physics
Best Student Paper:
Using Neural Networks to Model Electron-Nucleon Cross-Sections.
John A. Telfeyan, Department Physics and Astronomy, James Madison University

Honorable Mention:
Determination of Relative Concentrations of Hydrogen Isotopes.
Laurence A. Lewis, Department of Physics and Astronomy, James Madison University

Agriculture, Forestry, and Aquaculture
Best Student Paper:
Effects of Central and Peripheral Xenin Administration on Appetite, Feed Passage Rate, and Brain Chemistry in 4-Day Post Hatch Chicks.
Wint Nandar, Department of Biology, Radford University.

Honorable Mention:
Effect of Intracerebroventricular Administration of Neurotensin on Feed Intake in Goldfish.
Marissa L. Smith, Department of Biology, Radford University.

Biology with Microbiology and Molecular Biology
Best Student Paper:
The TVN0703 Protein from Thermoplasma volcanium, a Probable Archaeal Metal-dependent Serine/threonine Protein Phosphatase.
AbdulShakur H. Abdullah, Department of Biochemistry, Virginia Tech.

Best Student Paper:
Mapping of BGAF-binding Regions on the Maize b-glucosidase Isozyme Glu1.
H. Y. Yu, Department of Biological Sciences, Virginia Tech.

Best Student Paper:
Boundary Effects upon Population Distribution: Theoretical Model and Case Study.
Steven Hand, Department of Natural Sciences, Shenandoah University.

Honorable Mention:
A Study of the Proteome of the Apical Segment Membranes of Guinea Pig Spermatozoa.
Sara S. Hirsch, Department of Biology, Randolph-Macon College.

Biomedical and General Engineering
Best Student Paper:
Changes in Balance with Low Back Fatigue.
Bradley S. Davidson, School of Biomedical Engineering and Sciences, Virginia Tech.

Honorable Mention:
Mechanics and Structure of Vestibular Hair Bundles.
Corrie E. Spoon, School of Biomedical Engineering and Sciences, Virginia Tech.

Honorable Mention:
An Affordable Haptic Display for the Interpretation of 2-D Graphics by Individuals Who Are Blind or Have Visual Impairments.
David S. Burch, Department of Biomedical Engineering, Virginia Commonwealth University

Botany
Best Student Paper:
Phylogeny of the Genus Arachis.
Sheena A. Friend, Department of Biological Sciences, Virginia Tech.

Honorable Mention:
Phylogenetic Analysis of Phalaenopsis (Orchidaceae) Using Chloroplast DNA Sequences – an Update.
Yelena Lazdun, Department of Biological Sciences, University of Mary Washington.

Honorable Mention:
Sorocarp Formation in Polysphondylium: Altruism or Social Strife?
Carla D. Glass, Department of Natural Sciences, UVA-Wise.

Chemistry
Best Student Paper:
Preparation and Characterization of Hydrogenated Trimetallic Nitride Endohedrdal Metallofullerenes.
Wujunn Fu, Department of Chemistry, Virginia Tech.

Honorable Mention:
Predicting the Singlet Oxygen Quantum Yield of Humic Substances from Spectroscopic Properties.
Renee M. Dalrymple, Department of Chemistry, University of Mary Washington.

Honorable Mention:
Analytical Strategies Related to Accuracy and Precision in an ICP-MS Trace Analysis Problem in Instrumental Analysis.
Ashley M. Lakner, Department of Chemistry, James Madison University.

Environmental Sciences
Best Graduate Student Paper:
Evaluation of Fall Soil Sampling for Predicting Spring Infestation of Secondary Soil Pests in Corn.
Timothy A. Jordan, Department of Entomology, Virginia Tech.

Best Undergraduate Student Paper:
Comparative Analysis of the Impact of Development on the Health of Two Stream Tributaries of the Rappahannock River.
Justin Park, Department of Environmental Sciences & Geology, University of Mary Washington.

Honorable Mention:
An Assessment of the Water Quality of Crooked Run in Frederick, Clarke and Warren Counties, VA, Based on their Fish Populations.
Lyla H. Gray, Environmental Studies Program, Shenandoah University.

Best Undergraduate Student Poster:
Monitoring the Progress of a Wetland Mitigation Project for Cental Park in Fredericksburg, Virginia.
Michelle L. Arthur, Department of Environmental Sciences & Geology, University of Mary Washington.

Medical Sciences
Best Student Paper:
The Genetic Analysis of Ethanol-induced Anxiolysis in BXD Recombinant Inbred Mice.
Alexander H. Putman, Department of Pharmacology and Toxicology, Virginia Commonwealth University.

Honorable Mention:
Biodevelopment of Osteocytes from Mesenchymal Stem Cells Derived from Umbilical Cord Blood and Adult Bone Marrow.
Andrew P. Pacitti, Department of Physiology, Virginia Commonwealth University.

Honorable Mention:
FGF23 Regulation of 1-alpha-Hydroxylase in the Proximal Kidney Tubule.
Megan Forster, Department of Physiology, Virginia Commonwealth University.

Natural History and Biodiversity
Best Student Paper:
Effect of size and temperature on oxygen consumption in the hissing cockroach (*Gromphadorhina portentosa*).
Jeff W. Streicher, Department of Environmental Science and Policy, George Mason University.

Honorable Mention:
A Comparative Study of the Harvestmen of the Family Manaosbiidae (Opiliones, Laniatores) from Trinidad, W. I.
Daniel Proud, VA Wesleyan College.

Honorable Mention:
Experimental Effects of Forest Regeneration Methods on Salamander Populations up to 11-years Post-treatment.
Jessica A. Homyack, Department of Fisheries and Wildlife Sciences, VA Tech.

Psychology
Best Graduate Student Paper:
The Effects of Relative System Reliability and Prioritization on Alarm Reaction Patterns.
Elizabeth T. Newlin, Department of Psychology, Old Dominion University.

Best Undergraduate Student Paper:
Improving Memory in the Elderly Via Positive Feedback.
Kathryn Van Veen, Department of Psychology, Washington and Lee University.

Statistics
Best Student Paper:
A Semi-Parametric Approach to Robust Parametric Design.
Stephanie M. Pickle, Department of Statistics, Virginia Tech.

Honorable Mention:
Ranges of Measures of Association for Familial Binary Variables.
Yihao Deng, Department of Mathematics and Statistics, Old Dominion University.

Honorable Mention:
A Note on Latent Semantic Analysis as a Tool to Perform Correspondence Analysis.
Jayesh Srivastava, Department of Mathematics and Statistics, Old Dominion University.

CORRECTION
In the last issue of the Virginia Journal of Science, 57(3), the following table was incorrectly displayed on pages 141-142.

Jerry Bass distributed recent meeting revenue summary:

YEAR	SITE	GROSS MEETING REVENUE
2006	VT	($30,000 estimated)
2005	JMU	$37,137.11
2004	VCU	$58,652.55
2003	UVa	$48
2002	Hampton	$52
2001	JMU	$27,147.51

The correct table should read:

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2004	VCU	$58,652.55
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2001	JMU	$27,147.51

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